



April 24, 1992

BHA Company
PrecipTech, Inc.
Filtra GmbH

Los Angeles Department of Water & Power 111 North Hope Street, Room 604 Los Angeles, California 90012

Quote: LADOWP/BHAQU

ATTN: Ms. Karen Iseri

Dear Karen:

The following is a budgetary estimate to supply and install the acoustic horns for your unit No. 1 dust collector system. This is a G.E. Environmental Services, 19,008 bag (48 compartments of 396 bags each) reverse air dust collector. BHA is proposing installing 3 AH-25 acoustic horns in each of the 48 modules. BHA will provide the following labor, supervision, material, and equipment as follows:

A. LABOR AND SUPERVISION:

BHA will provide the following labor to install the 144 acoustic horns (3 horns per 48 compartments):

- . Lock out all equipment prior to beginning work.
- . Equipment and personnel to monitor gas levels in the modules $(0_2, 0_1, 0_2)$, combustible gasses) will be supplied by BHA services.
- . Pick up and transport all necessary materials required for the acoustic installation from a nearby staging area to the appropriate levels on the dust collector system.
- . Install the acoustic horn chain mount brackets under each walkway as identified by the acoustic engineered drawing for chain hanging of acoustic horns.
- Suspend each of the acoustic horns from chain and appropriate hardware to a critical distance from the tubesheet as specified on the acoustic engineered drawing.
- . Supply and install the internal plumbing to run from the acoustic horn in each module to the point in the module roof to penetrate to the penthouse area.
- Install the Y-strainer on the end of the piping connection inside the compartment.
- . Supply hookup of the stainless steel flex hose from the hard piping connection to the back of the horn driver after the plumbing has been completed and the lines have been blown out.
- . Penetrate the compartment roof and install a pipe nipple and seal weld as necessary to close the opening.

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Install the acoustic components as outlined on the acoustic engineered drawing (solenoid, locking ball valve, etc.). Connect the 48 modules of piping with a 1-1/2" diameter header system.

- . Run the 1-1/2" piping manifold to the ground level and connect to the compressor system. Install on the 1-1/2" piping manifold at the base of the collector, the necessary regulators and filter assemblies to properly drain the compressed air source of all moisture.
- . Compressor will be installed at base of collector on the current concrete slab and wired for operation.

B. <u>ELECTRICAL COMPONENTS AND LABOR:</u>

The following labor and material will be supplied to perform the electrical installation:

- . Supply and install an acoustic controller in the control room to properly monitor and control the acoustic horn system.
- . Supply and install the conduit and wiring to run from the acoustic controller to the locations of the solenoids in the penthouse of each of the banks of modules.
- . Pull the wire through the conduit and attach to the solenoids for electrical hookup of each compartment's horns.

C. SUPPLY AND INSTALL AIR COMPRESSOR:

The following equipment and labor will be furnished to supply and install the air compressor system:

- . A Quincy Model QMA-100 rotary screw air compressor will be supplied to provide the air requirements for the acoustic horn system. The following features are furnished on this compressor:
 - . Air cooled, oil cooler and after cooler
 - . 100 hp, 460 volt, 3-phase motor
 - . High temperature shutdown with dual probes
 - . Safety release valve
 - . Modulation with percent capacity gauge
 - . Auto dual control with time delay shutdown
 - . Enclosure over motor and cooling fan

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- . Mounted motor starter
- . Instrument panel with air discharge temperature gauge
- . Air discharge pressure gauge
- . Oil injection temperature gauge
- . Hour meter
- . Oil filter and separator differential pressure gauge
- . Power on light
- . Percent capacity gauge
- The rate of performance of this compressor is 495 CFM at 100 psig at 101.6 bhp.
- A Pioneer Model PHL500 heatless regenerative dryer will be supplied. The following features are supplied on this dryer:
 - . Initial supply of activated alumina desiccant
 - . Computer controlled diagnostic panel
 - . 110 volt electrics
 - . Pressure relief valve
 - . Visual moisture indicator
 - . Pressure gauge on each tower
 - . Updraft drying
 - . Stainless steel support screens
 - . ASME code vessels
 - . Adjustable purge flow valve
 - . NEMA 4 electrics
- A Pioneer Model CS600D coalescing pre filter will be supplied. This unit is required ahead of the regenerative dryer. This pre filter is equipped with a pressure differential gauge.
- A Pioneer Model PS500D particulate after filter will be supplied. This after filter is required after the regenerative dryer and is equipped with a pressure differential gauge.

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. One Manchester 400 gallon ASME code vertical tank with base ring and pressure relief safety valve will be supplied.

. All of these accessories will be supplied and installed at a location designated by Intermountain Power Service.

D. BHA SERVICES' CUSTOMER RESPONSIBILITIES:

Our service proposal is based on the following:

- . Easy access to all new bags and parts being provided. Parts are to be moved near the collector by the customer. A minimum 20% inventory for all replacement parts is usually recommended.
- . Disposal bins of sufficient capacity to contain all material which is to be discarded must be provided at the base of the collector. Disposal bins must be emptied in a timely fashion so as not to impede the work flow.
- . Hoppers must be emptied prior to crew arrival and throughout the duration of the job, as necessary.
- . "Free and easy" access of crew vehicles to the vicinity of the collector.
- . Customer to supply MSDS sheet on all equipment to be worked on prior to the start of the job.
- Power necessary for operation of required electrical tools (110 and 440 volt).
- . Compressed air source within 25' of the existing collector for operation of compressed air tools.
- . Use of customer facilities; i.e., restrooms, breakroom, showers, etc.
- . Customer personnel must be available to start and operate the collector fan during the course of inspections or upon completion of work so that our crew can inspect the unit, thereby ensuring an effective acoustic horn installation.
- . Customer representative must be available any time to inspect and approve work, before and during the job and immediately upon completion.
- Approval of non-union labor.

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E. PRICES:

Price for installation, piping, electrical, and air compressor for 48 compartments: \$250,000

All prices are exclusive of applicable taxes and/or freight. Terms are net 10 days upon completion of work. Process billing is applicable on work every 30 days. This proposal is subject to the Terms and Conditions attached. Prices quoted herein shall be firm for 30 days from the date of this proposal and are considered preliminary and budgetary.

NOTE: Additional charges may apply for delays which are not directly attributable to BHA Services, or not specifically stipulated in this proposal. This includes, but is not limited to, the following:

- 1. Removing major dust buildup over 2" or hard caked material from the tubesheet, housing or hopper walls, or hanging structure.
- 2. Replacing more than 10% of door seal material.
- 3. Any permanent repairs which require welding.

As a member of BHA Group, Inc., the BHA Services Division has, at its disposal, not only our own baghouse maintenance experience, but the practical and technical expertise developed over the last decade as original equipment manufacturers. The result is a reliability and level of expertise unparalleled in the baghouse maintenance industry.

By contracting with BHA Services for baghouse maintenance, we believe that the benefits derived by our customers include:

- . Decreased frequency of unscheduled downtime.
- . Increased bag life through proper bag installation.
- . Ensure proper working cleaning mechanism.
- . Leak-free operation upon completion of change-out.
- . Elimination of the personnel problems associated with in-plant personnel doing work which they don't want to do.
- . Peak load shaving of the in-plant maintenance crew work load, freeing them to work on production equipment while BHA Services refurbishes the air pollution control equipment.

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. Single source of responsibility for a complete and proper job, by way of the BHA Services guarantee.

. OEM installation of acoustic horn system ensuring trouble-free start-up and operation.

BHA ACOUSTIC SYSTEM SPECIFICATIONS

Acoustic Horn Type: AH-25 acoustic horn

Frequency Rate: 125 Hz
Powered Weighted Mean Frequency: 137 Hz
Sound Pressure Intensity at 1 Meter: 149 dB

Power Supply: 75 psig compressed air at

70-80 SCFM

No. of Horns per Compartment: 3
Total No. of Horns per System: 144

Materials of Construction:

Bell Housing: 7 gauge, 1018 plate steel, welded construction, White metal blast (SPC5), and paint with silicone alkyd primer.

Driver: East, welded, and machined construction, A-36 carbon steel. Zinc plated inside and out. Dual air inlet, 3/4" x 3/8" inlet orifice bushing. All machined surfaces are \pm .001".

Diaphragm Plate: High strength, heat treated stainless steel diaphragm plate. Surface hardness of Rockwell RC40 minimum.

Annealed condition tensile strength 150,000 psi maximum, flatness and concentricity \pm .005".

BHA ACOUSTIC SYSTEM PRICING

| Quantity | Description | Unit <u>Price</u> | Extended Price | | |
|----------|--|----------------------|-------------------|--|--|
| 144 | AH-25 Acoustic Horn | \$1,535.00 | \$221,040.00 | | |
| 144 | Mounting Assembly | \$ 55.00 | \$ 7,920.00 | | |
| 144 | 3/4" Manual Isolation Air Valve with Lockout | \$ 32.00 | \$ 4,608.00 | | |
| 48 | 1-1/4" Manual Isolation Air Valve with Lockout | \$ 48.00 | \$ 2,304.00 | | |
| 48 | 1-1/4" Solenoid Operated Air Valve | \$ 225.00 | \$ 10,800.00 | | |
| 144 | Flex Hose, Stainless Steel Braided - 3/4" | \$ 62.00 | \$ 8,928.00 | | |

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| Quantity | Description | Unit <u>Price</u> | Extended Price | |
|----------|--|----------------------|-------------------|--|
| 144 | 3/4" Cast Iron, Filter Screen | \$ 13.00 | \$ 1,872.00 | |
| 3 | 1-1/2" Air Filter with Auto Drain | \$ 185.00 | \$ 555.00 | |
| 3 | 1-1/2" Air Regulator with Pressure Gauge | \$ 140.00 | \$ 420.00 | |
| 1 | *Acoustic System Controller with Auto/ Manual Controls and Safety Key Lockout | | | |
| 1 | CAD Generated Installation Drawings | No Charge | No Charge | |
| 1 | Operation and Maintenance Manual | No Charge | No Charge | |
| | Total Price to Supply BHA's Acoustic System (1 Baghouse): | | \$258,447.00 | |

*This may be an optional item. Intermountain Power may wish to control the system through the existing PLC.

These figures are budgetary. Terms of payment and shipment can be discussed at a later date.

If you should have any questions, please call me on our Toll Free number (800) 821-2222. I will be contacting you by phone in the near future to discuss this letter.

Sincerely,

BHA GROUP, INC.

Andy Miller

Senior Sales Representative

AM: 14/LADOWP/BHAQU

w/Attachment

cc: Mark Santschi, Product Manager

BHA Group, Inc.



BHA Company PrecipTech, Inc. Filtra GmbH

TERMS AND CONDITIONS

- 1. PRICE AND PAYMENT The contract price F.O.B. place of shipment shall be the price set forth on the reverse hereof or in Seller's written proposal attached hereto (the "Proposal"). The quoted price is subject to change by Selter at anytime prior to acceptance of the Agreement by Buyer and thereafter in accordance with the terms of the Agreement. Payment in full for all services performed and for goods furnished will be due ten (10) days from invoice date which will generally be the date the services are performed and for the goods are shipped. Seller may, in its sole discretion, require a down payment or payment in full prior to performance of the services or shipment of the goods. Interest will be charged on all sums overdue at the rate of 1.8339/per month if permitted by law, otherwise at the highest lawful contract rate. All payments shall be made to Seller at 8800 East 63rd Street, Kansas City, Missouri 64133 or such other place as Seller may designate. If Buyer fails to make any payment as agreed, shows evidence of a changed financial condition or fails to perform any of his obligations, Seller may suspend its performance, without prejudice to any claims for damages Seller may be entitled to make, until satisfactory terms, conditions and security are received by Seller. conditions and security are received by Seller
- a changed infanciar conditions and security are received by Seller

 2. WARRANTIES AND LIMITATIONS OF REMEDIES: (a) All goods not manufactured by Seller shall receive only such warranty, if any, as is given by the manufacturer thereof. Any and all such warranties are hereby assigned to Buyer by Seller without recourse to Seller. (b) Seller warrants that the goods manufactured by Seller, except any "used" goods sold hereunder, shall be free from defects in material and fabrication for a period of one (1) year from the earliest of the date of shipment, the date shipment is placed on hold by Buyer, or such shorter period specified on the reverse hereof or in the Proposal, (c) Seller and sense to the express warranty (except such express warranty feelivered to Buyer by Seller, and then only when the Proposal or separate warranty is signed by a duty authorized officer of Seller). (d) THE FOREGOING EXPRESS WARRANTIES ARE IN LIEU OF ALL OTHER WARRANTIES. INCLUDING, WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTIABILITY AND FITNESS FOR A PARTICULAR PURPOSE. (e) Without limiting any other disclaimer contained in this paragraph 3, if Buyer purchases any air pollution equipment, Seller shall not be liable for damages caused by abrasion, corrosion, excessive temperature, condensation or moisture, chemical attack, particulate or gaseous emissions, fire, explosion, improper operation contrary to their instructions issued by Seller, insufficient maintenance, conditions on the control of Seller or operation of the equipment under different conditions than those stated in the operation's manual, specifications, or Proposal (f) Any "used" goods purchased hereunder are sold on an "ASIS, WHERE IS," besis without representation or warranty of any kind. (g) BUYER'S SOLE AND EXCLUSIVE REMEDY FOR SHEMENT OR, ATSELLER'S OPTION, TO REPLACE, F.O.B. PLACE OF SHIPMENT, ANY DEFECTIVE GOODS. Buyer will pey the cost of disassembling and returning the allegedy defective goods to Seller's sole of use amount not to exceed the amount page
- 3. CONTRACT CLAIMS ONLY: The Agreement provides the Buyer with contractual warranties and remedies with respect to any goods and services furnished hereunder. If Buyer has any claims against Seller with respect to any goods or services furnished hereunder, any such claims may be brought only in an action for breach of contract. Buyer shall not make any claim against Seller based on any theory of tort, including but not limited to strict liability or negligence theories
- 4. LIABILITY OF SELLER The total liability of Seller under the Agreement for breach of warranty, or for any other breach of the Agreement or for any claim related to goods or services furnished by Seller under the Agreement, and the Agreement for breach of warranty, or for any other breach of the Agreement or for any claim related to goods or services furnished by Seller under the Agreement, and the Agreement or for any claim related to goods or services furnished by Seller under the Agreement, and the Agreement or For the Agreement, and the Agreement or For the Cooks of For the Agreement or For the Agreement, and the Agreement or For the Agreemen PERFORMANCE OR NONPERFORMANCE OF THE GOODS OR SERVICES OR OF SELLER'S OBLIGATIONS UNDER THE AGREEMENT
- 5. INDEMNIFICATION BY BUYER: Buyer hereby agrees to indemnify, release, defend and hold harmless Seller, its directors, officers, employees, agents, representatives, successors and assigns, against any and allsuits, actions or proceedings at law or in equity (including the costs, expenses and reasonable attorneys' fees incurred in connection with the defense of any such matter) and from any and all claims, demands, losses, judgments, damages, costs, expenses or liabilities, to any person whatsoever (including Buyer's and Seller's employees or any third party) or damage to any property whatsoever (including Buyer's property) arising out of or in any way connected with either the goods or services provided under the Agreement, or Buyer's breach of its obligations hereunder, regardless of whether any act, omission, regiligence (including any act, omission or negligence relating to the manufacture, design, repair, rection, service, or installation of or warnings made or lack thereof with respect to any goods lumished hereunder) of Seller, its directors, officers, employees, agents, representatives, successors or assigns caused or contributed thereof. It Buyer fails to fulfill any of its obligations under this paragraph or the Agreement, Buyer agrees to pay Seller all costs, expenses and attorneys' fees incurred by Seller to establish or enforce Seller's rights under this paragraph or the Agreement. are in addition to any other rights or obligations set forth in the Agreement.
- 6. TAXES. The amount of any present or future tax based on the sale, use or contract price of the goods or services provided under the Agreement shall be paid by Buyer. Seller has the right at its option to pay any such tax and receive immediate reimbursement from Buyer
- 7. SHIPMENT: The goods sold hereunder are sold "F.O.B." place of shipment. Seller is authorized to make the necessary arrangements with the carrier for the delivery of the goods to the carrier at Seller's plant and the transportation by the carrier to Buyer. Risk of loss of the goods shall pass to Buyer upon delivery of possession to the carrier and Buyer shall bear the cost of shipment. Claims on account of error or shortage will not be considered unless made in writing immediately upon receipt of shipment. The goods shown on the invoice, packing list, and bill of lading shall govern settlements in all cases unless such notice of shortage is immediately reported to the agent of the delivering carrier, so that the alleged shortage can be verified, and like notice shall also be given Seller.
- 8. DELAYS IN SELLER'S PERFORMANCE AND BUYER'S REQUEST FOR DELAY IN SHIPMENT: Seller will use its best efforts to perform all services on the proposed service dates but cannot guarantee such dates since they depend upon personnel availability and prompt performance by Seller's suppliers. Seller shall be further excused for delays in performance of services or shipment of goods which result, in whole or in part from the acts or conduct of Buyer or third parties, or from strikes, lockouts or other differences with employees or any cause beyond the control of Seller including, but not limited to, fire, earth-quake, flood or windstorm, war, riot or embargoes, delays, losses or damages in transportation, or shortage or delay in receipt of cars, fuel, labor or material. If any such event occurs, the time of completion shall be extended accordingly. If, through no fault of Seller, delivery is delayed or postponed, Buyer shall pay to Seller any additional costs incurred by Seller arising from such delay or postponement, and the balance remaining unpaid on the contract price, after giving effect to such additional costs, shall become immediately due and payable. Buyer shall protect the goods against damage in case of delay or postponement. Seller may either store the goods on Seller's premises or ship the goods off seller is either case at Buyer's risk and expense.
- 9. CANCELLATION If Buyer desires to cancel an order for services and written notice of cancellation is received by Buyer at least five (5) days prior to the date the services are scheduled to be performed, Buyer shall pay to Seller a cancellation fee in an amount equal to the actual expenses incurred by Seller and expenses to which Seller has become committed for fulfillment of the services cancelled. If less than five (5) days notice of cancellation is provided, in addition to the above expenses, Buyer must pay to Seller a cancellation fee equal to 25% of either the agreed price or the time and materials estimate, as applicable. If Buyer desires to cancel in whole or in part an order for goods (except custom goods or goods that have been modified to Buyer's specifications), Buyer shall pay to Seller a cancellation fee in cash equal to 25% of the purchase price of such goods. Buyer may not cancel an order after shipment. Buyer may not cancel an order for custom goods or goods that have been modified to Buyer's specifications.
- 10. ACCEPTANCE AND INTEGRATION / MODIFICATION AND WAIVER: This document, the Proposal, and any separate written warranty signed and accepted by a duly authorized officer of Seller, are intended by the parties as a final expression of their agreement and also as a complete and exclusive statement of the terms of their agreement and are referred to herein as the "Agreement." Without limiting the toregoing, no additional or conflicting provisions in Buyer's documents shall be deemed a part hereof. No affirmation, representation or warranty made in Seller's advertising or by any agent, employee or representative of Seller which is not specifically included within the Agreement is a part hereof. No course of prior dealings between the parties, no usage of the trade, no representations by Seller's agents or in Seller's advertisements shall be relevant to supplement or explain any term used in the Agreement. Acceptance of or acquiescence in a course of performance rendered under the Agreement shall not be relevant to other manual conditions in this document, shall be evidenced by any one or more of the following: (i) Buyer's signature on this document or any proposal to which these terms and conditions are made applicable. (ii) Buyer has in any tasks in any manual authorized shipment of the cords or performance and the services or till Buyer has naid the ourchase price or any portion thereof. The Agreement can regreement, including the terms and conditions in this occurrent, shall be evidenced by any one or more or the looking; (i) suyer is signature on this occurrent or any proposal to which these terms and conditions are made applicable, (ii) Buyer has paid the purchase price or any portion thereof. The Agreement can be modified or rescinded only by a writing signed by a representative of Buyer and a duly authorized officer of Seller. No claim or right arising out of a breach of the Agreement can be discharged in whole or in part by a waiver or renunctation of the claim or right unless the waiver or renunctation is supported by consideration and is in writing signed by the aggreeved party. Waiver by Seller of any breach or breaches hereunder by Buyer shall not be deemed a continuing waiver of such breach nor as a waiver of or permission for any subsequent breach.
- 11. SEVERABILITY. The invalidity or unenforceability of any provisions of the Agreement shall not affect the other provisions hereof, and the Agreement shall be construed in all respects as if such invalid
- 12. LIMITATION OF ACTIONS / ASSIGNMENT AND SUCCESSOR: Any action for breach of the Agreement or otherwise related to or arising out of the services performed hereunder or the goods provided pursuant hereto must be commenced within one (1) year after the cause of action has accrued. The Agreement shall be binding upon and inure to the benefit of the parties hereto and their heirs, personal representatives, successors and permitted assigns. Buyer may not assign any of its rights or obligations under the Agreement without the prior written consent of Seller.
- 13. CHOICE OF LAW AND CONSENT TO JURISDICTION: THE AGREEMENT SHALL BE MADE AND ENTERED INTO AND SHALL BE GOVERNED BY AND CONSTRUED UNDER THE LAWS OF THE STATE OF MISSOURIL Any reference herein to the "Uniform Commercial Code" is to said Code as adopted in Missouri and in effect on the date of the Agreement. Terms used herein that are defined in the Uniform Commercial Code shall have the meanings contained therein. Buyer consents to the jurisdiction of the courts of Missouri with respect to any action for breach of the Agreement and any other action in anyway related to the goods or services provided hereunder. Buyer agrees that any action filed by Buyer in another jurisdiction may be removed to Missouri.
- 14. HEADINGS FOR CONVENIENCE: The paragraph headings are used for convenience only and shall not be used in interpreting the Agreement

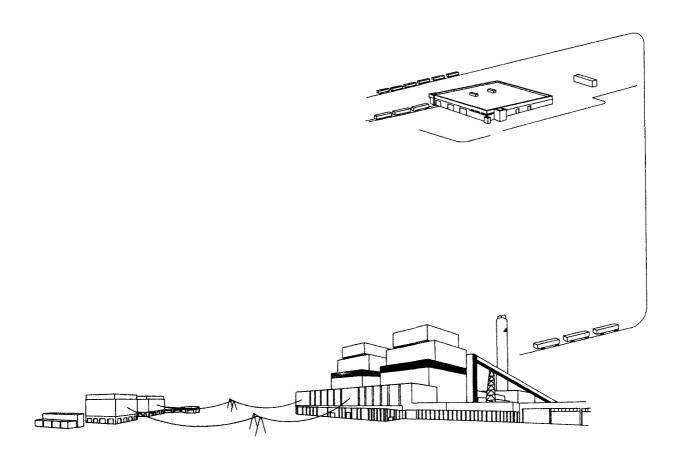
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INTERMOUNTAIN POWER SERVICE CORP.





Evaluation of
Sonic-Horn-Assisted
Reverse-Air Cleaning
of the Fabric Filter Bags

January 14, 1991

Acknowledgements

This testing program was completed through the efforts of many people and the author gratefully acknowledges their help.

Maintenance personnel planned, scheduled and then installed air lines to the horns and hung the horns well above the compartment tubesheet but below the compartment walkway. These jobs were not convenient or easy. They also helped a number of times in opening doors, weighing bags, and pulling and replacing bags for testing. Electrical cable was pulled from the baghouse to the scrubber and connectors attached.

I & C installed a data acquisition system and individual bag flow monitors in two different compartments. They were also ready and willing with just a call to troubleshoot, calibrate and keep the system running. Many hours and extra effort were required to complete the testing.

Operations assisted in the gathering of data for months and was willing to let us do the testing. They also spent a good deal of time without Compartment B2, hung tags and pulled tags again and again and even tried to help me count the number of ash pulls before and after sonic-assisted cleaning.

Drafting personnel from Technical Services spent more than a few days drawing up the plans, making charts and helping with sonic pressure level testing.

Engineering supervision was understanding and encouraging even with numerous delays and setbacks.

THANKS to EVERYONE for their interest, support, hard work and help!

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I. Recommendations and Conclusions

Sonic Horns should be installed in each compartment of the baghouse to assist reverse-gas cleaning. Sonic-horn-assisted reverse-gas cleaning will decrease the residual dust cake, lower the differential pressure, decrease the input power required to run the induced draft (ID) fans and allow us to get out of a continuous cleaning cycle.

The installation and operation of sonic horns has a Benefit/Cost Ratio of 1.83 and the project payback period is 8.7 years. This economic evaluation was done using the following information:

- Annual savings of \$189,000.00 per year in reduced input power to the induced draft fans. This reduction is due to a decrease in baghouse casing differential pressure of 1.5 inH₂O.
- Project costs are estimated to be \$1,440,000.00.
 Engineering labor will cost \$20,000.00, installation labor will cost \$720,000.00 and material costs will be \$700,000.00.
- Operation and maintenance costs are estimated to be \$24,000.00 per year.
- A 1.0 inH₂O decrease in baghouse casing differential pressure reduces input power to the ID fans by 712 KW and results in a \$63,000.00 per unit per year savings. These results are from a test on Unit 1 and were calculated using a station availability of 94.71%, a net output factor of 97.05% and a cost savings of 1.1 cent per kwh (variable fuel cost).

Sonic horns should be approved for bidding by meeting the restrictive EPRI guidelines for "ideal" or "effective" horns and through onsite testing. The sonic horns should be tested in the baghouse to get an accurate picture of their effectiveness and also determine the number of horns of each manufacturer required in each compartment to do an acceptable job. This is the only way to get sonic horns that will do the job and competitively bid the project in a way that people can bid fairly against each other.

EPRI's requirements for an "ideal" horn are as follows:

- Power-weighted mean frequency below 250-300 Hz,
- Geometric standard deviation less than 2.0 and
- Integrated sound pressure of approximately 140 dB at a point 3 feet from the bell mouth.

EPRI's requirements for an "effective" horn are as follows:

- Fundamental Frequency below 300 Hz,
- Integrated sound pressure level in range below about 300 Hz of at least 134 dB at a point 3 feet from the bell mouth.

Baghouse fabric filter bag residual dust cakes were reduced by an average of over 13 pounds by the use of sonic horns during cleaning. This is a reduction in areal density of .13 lbs/ft². One of the two fabric testing facilities also report reductions in embedded dust and an increase in "as-received" permeabilities of 28.7% in a bag cleaned with the sonic horns.

The initial effect of using the sonic horns was dramatically positive. Calculations of the expected baghouse casing differential pressure reduction resulted in a conservative 2.0 inH₂O drop. The economic benefit was calculated using a 1.5 inH₂O pressure drop to take into account the low differential pressures that will be seen when the baghouse has new bags. The increased flue gas flow rate seen initially during the test was sustained for over a two month test period.

Sound pressure level testing showed that three BHA Group, Incorporated's AH-25 sonic horns provided good sound levels throughout Compartment B2. Only one of 24 locations had an average integrated sound pressure level below EPRI's recommendation of 132 dB. The three sonic horns used during the sound pressure level testing were not in good locations for uniform sound distribution but still provided adequate sound pressures.

Extra attention should be given to providing very clean air to the sonic horns and providing easy access to the horns for maintenance. Two of the five horns stopped working because of debris under their diaphragms. Also, the horns were difficult to work on in their current test situation because they hang 26 feet above the walkway and no provisions were made to access them through the walkway or to be able to hoist them up.

II. Introduction and Test Objective

Problems with high baghouse differential pressures came to a peak during the summer of 1990. The pressure transducers for the baghouse casings inlet pressures were out of range and hiding the fact that the casing differential pressures were 7.5 to 9.0 inH $_2$ O. The bypass point for the casing differential pressure had to be raised from 8.4 inH $_2$ O to prevent us from bypassing the baghouse.

Cleaning cycles did not bring the casing differential pressures below 5.4 inH₂O, which is the initiation point for a cleaning cycle; therefore, the casings were in a continuous cleaning cycle at full load.

The investigation into the cause and solutions to the high differential pressure resulted in many positive discoveries.

- The inlet control dampers on the reverse air fans were opened up to allow the recommended flow rate. The higher flow rate was not necessary during startup to keep the bags clean.
- The actuators for the inlet control dampers for the reverse air fans need to be watched closely because they frequently fail and there is no abnormal indication in the control room. Flow meters are going to be installed in the reverse air duct and any abnormal operation will be indicated in the control room. An investigation is currently under way to see if these actuators need to be larger.
- More thorough outage inspections of inlet, outlet and reverse air dampers showed that many of these were failing and needed attention each outage.
- Bag testing showed that the filter bags were in excellent mechanical condition with no chemical degradation, very high strengths and flex lives and that the tensioning was good. The bags did show, however, low permeabilities and a lot of fines.
- The filter bags in Unit 2 were shook by hand in June 1990 and showed a surprisingly sudden decrease in differential pressure of over 2.0 inH₂O.
- A representative from GEESI came and inspected the facility and operation in July of 1990. A high differential pressure cleaning of a casing showed just over an 1.0 inH₂O pressure drop recovery. GEESI's representative concluded that the high differential pressure was caused by

the buildup of fines in the interstices of the bag fabric and they recommended that we test sonic horns.

• GEESI sent some of our ash gathered from their visit in July of 1990 to Southern Research Institute (SRI) for an ash analysis and comparison to the ash gathered when SRI was onsite during the startup of Unit 1's baghouse. The analysis showed that the particle size distribution of the ash has changed since 1987. The median diameter of samples taken in July 1990 were 6.22 micrometers for Unit 1 and 6.99 micrometers for Unit 2 compared to 9.71 micrometers for Unit 1 in 1987. Differences in particle size could cause the higher differential pressure.

Even with the observed good operation, increased attention and improvements, the casing differential pressures at full load remain between 7.0 to 8.0 in $\rm H_2O$ and we are in a continuous cleaning cycle.

An investigation into replacement procedures for the fabric filters showed that, because of the high cost of rebagging the baghouse, the only significant reasons for rebagging the baghouse would be casing differential pressures that were too high or concern over wide spread failures of the filter bags. Also, bag testing has shown that, with the excellent condition of our filter bags, a filter bag life of 10 years may be possible if high casing differential pressures do not force rebagging the baghouse sooner.

The initial performance tests done on the baghouses and subsequent testing in September 1991 have indicated the flue gas flow rates, particulate loading and baghouse efficiencies and performance are within design specifications and performance guarantees. Only the casing differential pressure performance guarantee of 6.8 inH₂O for 100% maximum continuous rating is a problem.

EPRI reported in March of 1990, that reverse gas cleaning with sonic assistance is the cleaning method of choice for full-scale, low-ratio utility baghouses. Since 1984, 17 of 50 low-ratio baghouses using reverse-gas cleaning and operating downstream from pulverized coal fired boilers have installed sonic horns to help maintain a lower baghouse pressure drop. Reported pressure drop reductions were from 1 to 3 in $\rm H_2O$.

With the above information in mind, an evaluation of sonic-horn-assisted reverse-gas cleaning was proposed. The objective of the evaluation would be to determine if the sonic horns could be effective in our baghouses, quantify the effectiveness and then determine if the sonic horns are economically justified.

III. Test Plan

The test plan followed was similar to that recommended in the EPRI report, "Volume 2, Sonic Cleaning Guidelines," on page 3-3. This report in included in Appendix B. The sonic horn testing consisted of the following:

Before Sonic Horn Operation

- 1. Install individual bag flow monitors (IBFMs) and Sonic Horns in Unit 2 Compartment B2.
- 2. Install IBFMs in Unit 2 Compartment B4.
- 3. Establish baseline flowrates through the IBFMs and record compartment differential pressures before operating the sonic horns.
- 4. Determine the number of fly ash pulls that are required to empty the hoppers under Compartments B2 and B4 after a specific length of time in service and the unit operating at good repeatable test conditions. This should backup flowrate data taken in Step 3.
- 5. Do bag weight surveys in both Compartments B2 and B4 and take out two filter bags from each compartment to send to outside laboratories for permeability testing before sonic horn operation.

During Sonic-Horn Assisted Cleaning

- 6. Put the sonic horns in service and monitor the effects.
- 7. Establish flowrates through the IBFMs with the sonic horns in service and see what effect, if any, sonic horns have on the compartment and casing differential pressure.
- 8. Determine the number of fly ash pulls that are required to empty the hoppers under Compartments B2 and B4 after a specific length of time in service and the unit operating at good repeatable test conditions. This should backup flowrate data taken in Step 7.
- 9. Do bag weight surveys in both Compartments B2 and B4 and take out two filter bags from each compartment to send to outside laboratories for permeability testing.
- 10. Do sound pressure level testing in Compartment B2 to determine how many horns are required for our installation and verify that sound pressure levels are at recommended levels.

Economic Evaluation

11. Using information about the required number of horns per compartment, that was determined in Step 10, estimate the cost of installing a sonic horn system.

Economic Evaluation continued

12. Evaluate the test results to quantify the benefits of installing sonics horns for cleaning and use them in an economic evaluation of the project.

IV. Description of Test Equipment

Installation of numerous pieces of equipment and instrumentation was required to complete an evaluation of sonic-horn assisted cleaning of the baghouse. Sonic horns were installed in Compartment B2, individual bag flow monitors (IBFMs) were installed in Compartments B2 and B4 and a data acquisition system was installed to keep track of important test parameters.

Sonic Horns

The sonic horns used in this test were provided by BHA, Group Incorporated at no cost. These horns were chosen as a test case because they meet the qualifications of "ideal" horns as given by EPRI on page 2-9 in their report, "Sonic Cleaning Guidelines," which is included in this report as Appendix B. An "ideal" horn is described as follows:

- Power-weighted mean frequency (PWMF) below 250-300 Hz.
- Geometric standard deviation less than 2.0.
- Integrated sound pressure of approximately 200 Pa(140 dB) at a point 1 m from the bell mouth.

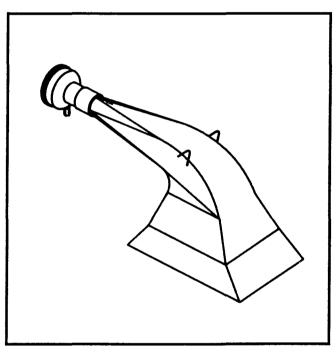
At the time of the EPRI report the horns which were installed were called the Envirocare 125. The report shows, on Page B-5, that the Envirocare 125 sonic horn has a PWMF of 179 Hz, a geometric standard deviation of 1.59, an integrated sound pressure level of 141.9 dB and uses 59 scfm at an air supply of 60 psi. The five sonic horns installed in Compartment B2 are the BHA Group, Incorporated's Model AH-25. The current BHA Group, Incorporated's literature on the AH-25 horn, shown as Figure 1, reports the following:

- Power-weighted mean frequency (PWMF) is 137 Hz,
- Integrated sound pressure of 149 dB and
- Air Consumption of 75 scfm at an air supply pressure of 75 psi.

The AH-25 sonic horns were installed according to BHA Group's recommendations. The installation drawings from BHA Group and IPSC's installation drawing are included in Appendix D. The sonic horns were installed below the upper walkway approximately 26 ft above the tubesheet in Compartment B2. Five sonic horns were installed; Two sonic horns were installed in the south walkway, one sonic horn was installed in the middle of the middle walkway and two sonic horns were installed in the north walkway. The air supply was connected to the plant's service air system. A 1-1/2-inch air line was extended from the tube sheet level through a pressure regulator and manual block valve up to the upper access doors. Each sonic horn was then supplied with air through a 3/4-inch manual ball valve and line.

Advanced Acoustic Horn Technology

The AH-25 is rated as one of the most powerful horns available. With 149 decibels of power and a unique bell design for enhanced sound, BHA's patented AH-25 is engineered for large structural baghouses and storage silos to provide greater cleaning efficiency and material movement. Design-engineered and field proven, the AH-25 delivers maximum acoustic energy to help lower differential pressures, increase airflows and improve the overall performance of your air pollution control or material storage equipment.



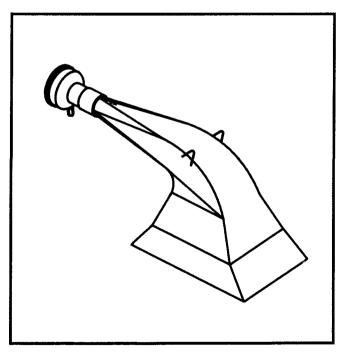
AH Series Acoustic Horn Model AH-25

Figure 1 - Manufacturer's literature describing the sonic horns installed in Unit 2's Compartment B2.



Advanced Acoustic Horn Technology

The AH-25 is rated as one of the most powerful horns available. With 149 decibels of power and a unique bell design for enhanced sound, BHA's patented AH-25 is engineered for large structural baghouses and storage silos to provide greater cleaning efficiency and material movement. Design-engineered and field proven, the AH-25 delivers maximum acoustic energy to help lower differential pressures, increase airflows and improve the overall performance of your air pollution control or material storage equipment.



AH Series Acoustic Horn Model AH-25

Model AH-25*Specifications/Dimensions

Frequency: 125 Hz
Power Weighted Mean Freq. 137 Hz
Sound Pressure Level: 149 dB

Material: A36 Carbon Steel

(stainless steel available)

Max. Operating Temp: Weight:

650°F (350°C) 110 lbs. (50 kg)

Air Consumption:

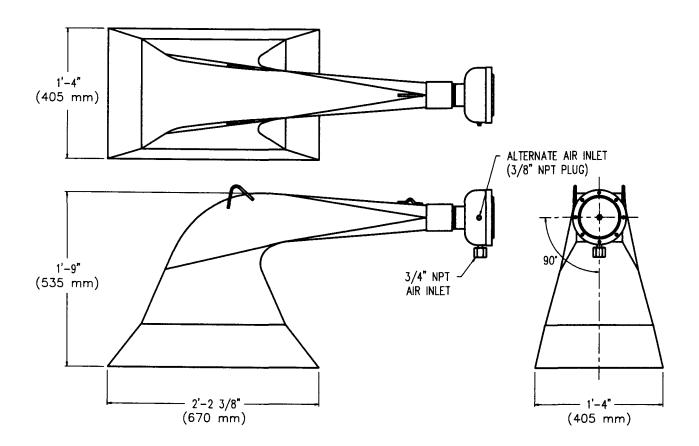
75 SCFM @ 75 PSI (35 l/s @ 6,2 bar)

Applications:

Structural baghouses,

storage silos

* Patent Pending



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Five horns were installed in Compartment B2 estimating that no more than five horns would be required. EPRI recommends that a ratio of one horn for each 3000-8000 ft² of fabric be used for horn evaluations. One compartment in IPP's baghouse contains 396 filter bags that contain an effective filter cloth area of 97.91 ft²; therefore, one compartment has 38,772 ft² of effective filter cloth area. Five horns per compartment is equivalent to a ratio of one horn for each 7755 ft² of filter cloth area. For an application with low sulfur coal, with fly ash with low cohesivity and low areal densities, a ratio of one horn for each 7755 ft² of filter cloth area was expected to be adequate.

Individual Baq Flow Monitors (IBFM)

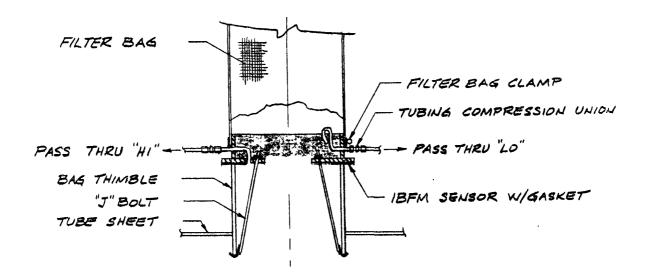
Five individual bag flow monitors (IBFM) were installed in both Compartments B2 and B4 in Unit 2. The IBFMs are orifice meters for single bag locations and have a 5 inch diameter orifice. The IBFMs were purchased from ETS, Inc. and a data acquisition system was also rented to keep track of the IBFM data as well as other key baghouse parameters. Figure 2 shows a sketch of an IBFM as well as a picture of the installation. The restriction across the orifice is slight and the differential pressure measured is less than 0.5 inH $_2$ O; therefore, a representative flow rate is able to be calculated.

Compartment B2 in Unit 2 is the compartment with the 5 sonic horns and 5 IBFMs installed in it. Compartment B4 in Unit 2 had 5 IBFMs installed in it and is being used as an experimental control so that any increase in flow rate in Compartment B2 can be attributed to the use of sonic horns and not operational changes and that fact could be verified by data taken in Compartment B4. Figures 3 and 4 show the installed locations of each IBFM and their assigned number in the data acquisition system.

Data Acquisition System

A data acquisition system and Baghouse Performance Monitor Expert System software were rented from ETS, Inc. to help in the sonic horn evaluation. The data recorded by the system are as follows:

- IBFM data are taken from one IBFM at a time and could be set to one IBFM or set to sequence through all 10 IBFMs.
- Compartment Differential Pressure is taken for the Compartment which contains the IBFM that is being recorded. IBFMs 1-5 are in Compartment B4 and IBFMs 6-10 are in Compartment B2.
- Compartment temperature is recorded for the compartment which contained the IBFM that is being recorded.
- Casing B differential pressure was recorded from the original equipment signal.

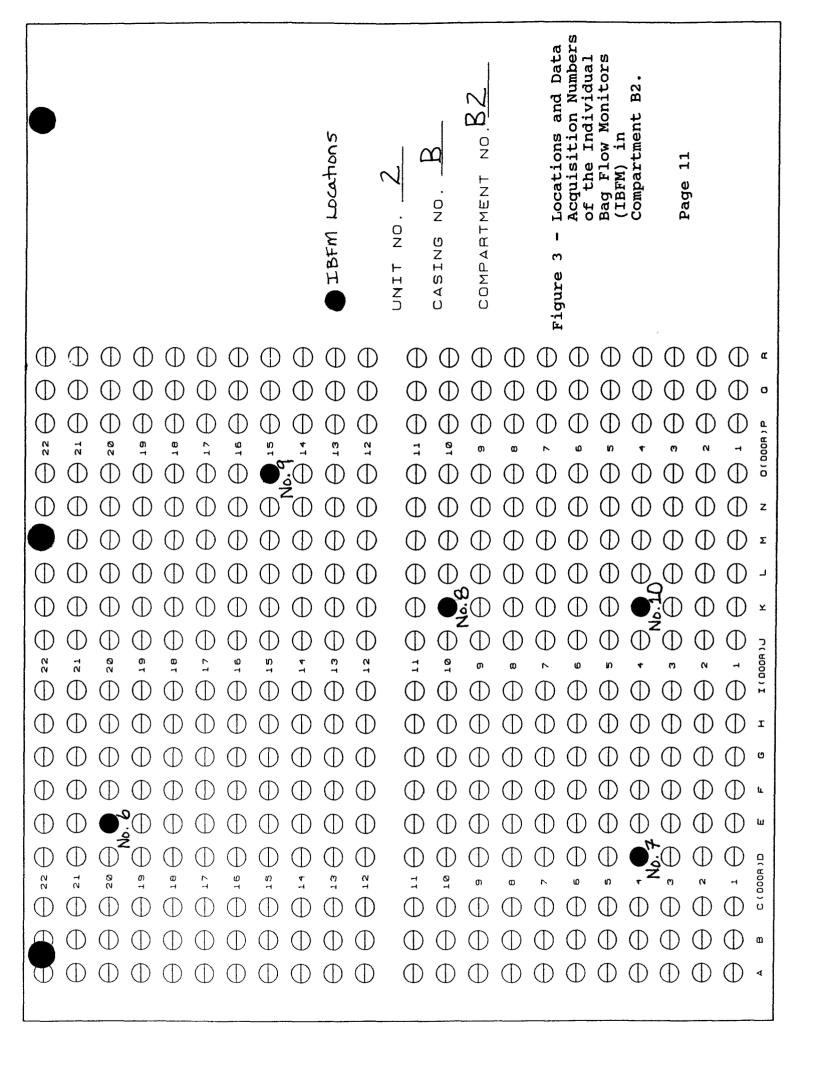


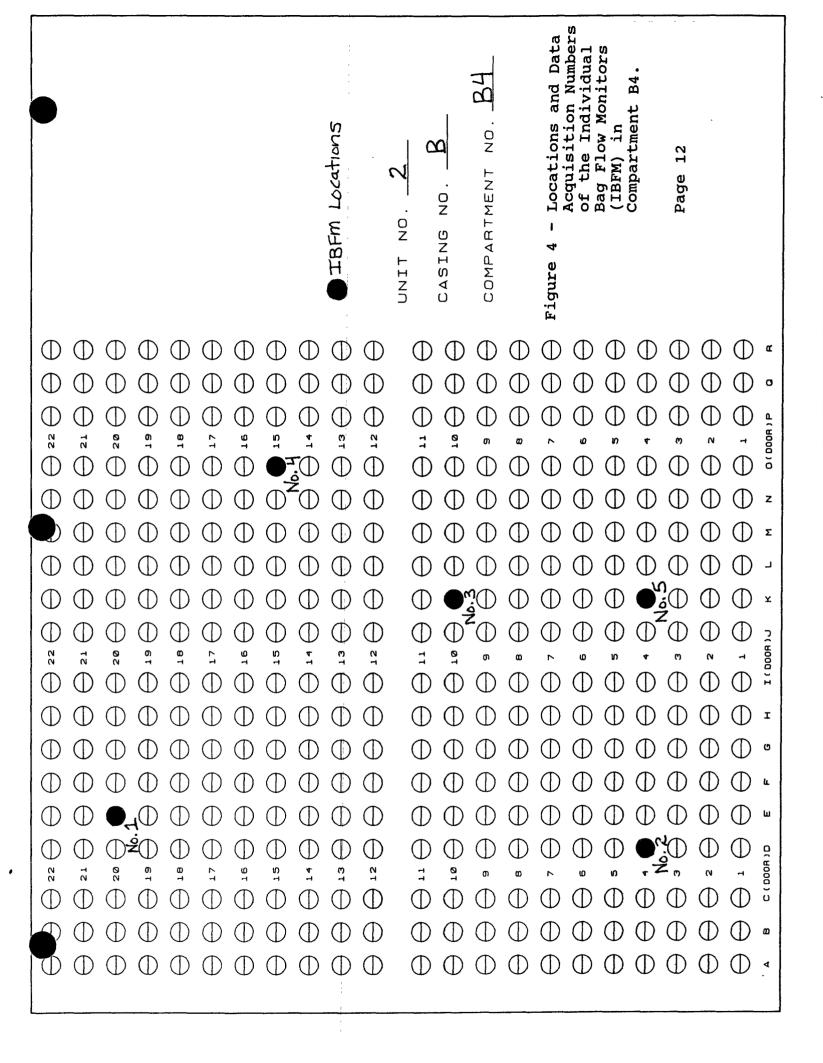
Sketch of IBFM orifice meter. The IBFM is attached to a bag thimble using three "J" bolts and the filter bag is attached to the IBFM using a hose clamp. The IBFM has a 5.0 in. diameter orifice.



Picture of IBFM installation. The tubing connections for measuring differential pressure across the orifice are shown.

Figure 2 - ETS, Inc.'s Individual Bag Flow Monitor (IBFM)





Data Acquisition System continued

- Unit 2's gross load in MW is recorded from the scrubber panel meter.
- Casing B total outlet flue gas flow rate was recorded from the existing Annubar flow meter.
- Casing B outlet opacity was recorded from the original equipment opacity meter.

The software was normally set up to take data at 10 second intervals and to sequentially rotate through the IBFMs in three minute intervals. The calibration of the IBFM pressure transmitters was rather difficult because of the small pressures involved. The Baghouse Performance Monitor Expert System software is not well suited for adaptation for a testing program and the functionality turned out to be less than anticipated but, the system did provide enough reliable information to complete the testing and analysis.

V. Test Results and Calculations

The testing program showed definite positive results. The sonic-horn-assisted reverse-gas cleaning of the bags in Compartment B2 showed:

- · An increased flue gas flow rate,
- · Lower compartment differential pressure,
- · Much lower fabric filter bag weights,
- Higher permeability and lower embedded dust in one laboratory tested filter bag and that
- Three BHA Group, Inc.'s AH-25 sonic horns provided EPRI's recommended sound pressure levels throughout Compartment B2.

A calculation of the predicted decrease in casing differential pressure, if sonic horns are installed in each compartment, is then presented using the above results.

Increased Flue Gas Flow Rate

The sonic horns were first used in Compartment B2 on April 10, 1991. Figure 5 shows a plot of the differential pressure through IBFM #6, which is located in Compartment B2, from about 9:15 a.m. on. The flue gas flow rate is proportional to the square root of the differential pressure. Figure 6 shows a plot of the gas-to-cloth ratio, which is the flue gas flow rate through one filter bag divided by the filter area of one filter bag. The sonic horns were first used in the cleaning cycle at 11:09 a.m. and it is obvious from Figures 5 and 6 that the sonic horns were very effective in cleaning the filter bags and causing the large increase in flue gas flow rate.

The change in flue gas flow rate can be calculated approximately from Figure 6 or from tabulated values for gas-to-cloth ratio included in Appendix G. If we take values of gas-to-cloth ratio just after a cleaning cycle, a reasonable before sonic-horn value would be 1.80 ft/minute and a reasonable after sonic-horn value would be 2.55 ft/minute. The flue gas flow rate increased by over 40% by using sonic horns.

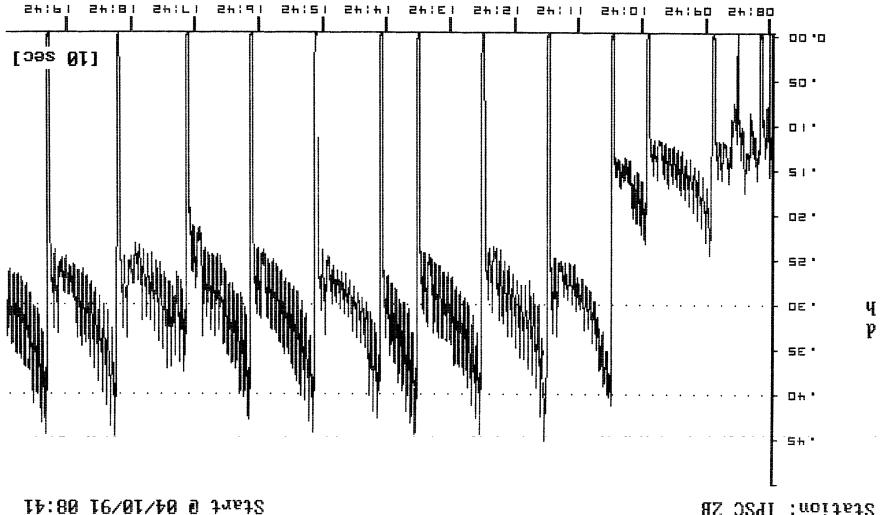
The flue gas flow rates shown are representative of what was seen during the whole testing program, and the increase because of sonic-horn-assisted reverse-gas cleaning was sustained for over two months of testing.

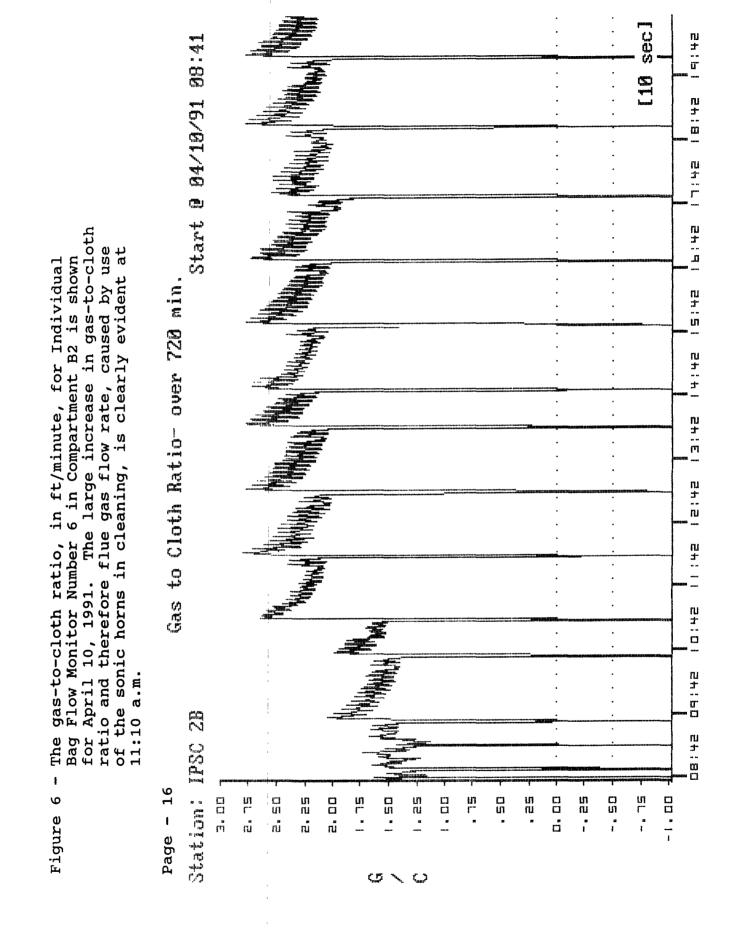
As a back up measure to the change in flue gas flow rate provided by the IBFMs, it was attempted, unsuccessfully, to count the number of fly ash pulls required to empty the hoppers under Compartments B2 and B4. Fly ash transfers were found to be too erratic.

in cleaning is clearly evident at 11:10 a.m. differential pressure caused by use of the sonic horns is shown for April 10, 1991. The large increase in Individual Bag Flow Monitor Number 6 in Compartment B2 Figure 5 - The differential pressure, in inH_2O_1 across

bgde - 12

Station: IPSC ZB .nim OST revo -db MT81





Lower Compartment Differential Pressure

Compartment differential pressure is a measure of the pressure drop across the thimble, the filter cloth and the dust cake. pressure drop across the thimble and from the filter cloth should stay fairly constant under normal conditions but the pressure drop across the dust cake will vary with the thickness of the dust Figure 7 is a plot of Compartment B2's differential pressure on April 10, 1991. It is obvious that Compartment B2's differential pressure decreases dramatically at 11:10 a.m., which was when the sonic horns were first used to clean the bags. only part of the compartment differential pressure that could show such a large decrease is the thickness of the dust cake. should also be noted that, as shown in Figures 5 and 6, the decrease in compartment differential pressure happened at the same time there was a 40% increase in flue gas flow rate. An increase in flow rate causes a higher differential pressure.

The lowest compartment differential pressure shown on Figure 7 before the sonic horns were used is approximately 6.0 inH $_2$ O and a conservative value for after using the sonic horns is 5.25 inH $_2$ O. The sonic horns decreased Compartment B2's differential pressure 0.75 inH $_2$ O even with a 40% increase in flue gas flow rate.

Lower Fabric Filter Baq Weights

Fabric filter bag weights were measured on over 40 filter bags in Compartments B2 and B4 on four different occasions. The weights were taken using a digital hand-held hook scale. The 75 pounds of spring tension was released as gently as possible from the bags to be weighed. Then, the hook was inserted in the flat bar that is hooked to the bag cap and the bag was lifted and weighed. Two pounds was subtracted from the weight shown on the scale to account for the weight of the flat bar. On all but the first bag weight survey in Compartment B2 and on every bag weight survey in Compartment B4 the bags were weighed with the filter bags still on the thimbles. On the first bag weight survey in Compartment B2, February 4, 1991, all the filter bags weighed were taken off their thimbles. This practice was discontinued because of the increased handling of the bags and the additional ash it knocked off.

The data sheets showing the locations of the bags weighed and their weights from the bag weight surveys for both Compartments B2 and B4 are included in Appendix E. Table 1 shows the tabulated results of the bag weight surveys for Compartment B2. The average bag weight shown for February 4, 1991, which is before the sonic horns were used, is 45.4 lbs. This is somewhat lighter than it might have been because of the increased handling of the bags when they were taken off of their thimbles. The average bag weights shown for the three bag weight surveys done during

secl 1 1 1 1 1 Start @ 04/10/91 00:41 t t co コニナ 一口二十四 differential pressure, caused by use of the sonic horns Compartment B2's differential pressure, in inH_2O , is The large decrease in Comp. Delta P- over 728 min. is clearly evident at 11:10 a.m. 二十二十二 shown for April 10, 1991. in cleaning, Station: PSC 2B . 1 ເກ ເນ ຕື **5** n U . . . t. រា កា e E 10 10 11 m. 0 18 ញ ព . . . t in b. 50 រ រ Figure Page INC

BAG WEIGHT SURVEYS FOR COMPARTMENT B2, UNIT 2

| Bag Weights are in pounds, lbs. | | Before using Sonic Horns | While using Sonic Horns | | | |
|---------------------------------|--------------|-----------------------------|-------------------------|---------|---------|--|
| | Date | 2/4/91 | 4/30/91 | 7/15/91 | 9/24/91 | |
| | Bag Location | | | | | |
| 1 | A-1 | 39.3 | 31.6 | 32.4 | 30.7 | |
| 2 | A-12 | 41.1 | 28.3 | 28.7 | 28.4 | |
| 3 | A-21 | | | 29.1 | 30.0 | |
| 4 | B-1 | 39.5 | 31.1 | 35.4 | 31.9 | |
| 5 | B-12 | 45.0 | 31.5 | 30.0 | 29.9 | |
| 6 | B-21 | | | 30.9 | 30.9 | |
| 7 | C-1 | 46.6 | 32.9 | 34.0 | 31.6 | |
| 8 | C-12 | 45.7 | 29.3 | 29.3 | 28.9 | |
| 9 | C-21 | | | 28.9 | 28.0 | |
| 10 | D-1 | 44.5 | 33.5 | 34.9 | 33.6 | |
| 11 | D-2 | | | 35.1 | 34.8 | |
| 12 | D-3 | | 1 | 35.4 | 34.7 | |
| 13 | D-4 | | 33.1 | 34.7 | 34.6 | |
| 14 | D-11 | 48.1 | 31.2 | 30.3 | 30.1 | |
| 15 | D-16 | 46.3 | 28.0 | 29.5 | 27.4 | |
| 16 | D-17 | 42.5 | 29.1 | 28.2 | 27.8 | |
| 17 | D-18 | 44.1 | 28.4 | 27.9 | 27.5 | |
| 18 | D-19 | 42.3 | 27.7 | 28.4 | 27.0 | |
| 19 | D-20 | | 29.6 | 28.1 | 27.4 | |
| 20 | E-1 | | | 34.9 | 34.7 | |
| 21 | E-11 | 48.7 | 32.0 | 30.9 | 31.3 | |
| 22 | E-16 | 45.5 | 29.6 | 30.7 | 30.1 | |
| 23 | E-17 | 43.9 | 30.7 | 30.6 | 29.1 | |
| 24 | E-18 | 45.6 | 28.9 | 29.5 | 28.7 | |
| 25 | E-19 | | 28.6 | 26.8 | 27.3 | |
| 26 | E-20 | | 30.6 | 27.9 | 28.2 | |
| 27 | F-1 | | | 34.4 | 34.8 | |
| 28 | F-11 | 46.2 | 33.0 | 30.9 | 32.1 | |
| 29 | G-11 | 43.7 | 31.1 | 27.2 | 28.8 | |
| 30 | H-11 | 51.6 | 31.6 | 31.6 | 31.4 | |
| 31 | I-10 | | 30.8 | 30.9 | 29.5 | |
| 32 | I-11 | 44.4 | 30.0 | 31.6 | 29.5 | |
| 33 | J-1 | 47.4 | 32.0 | 33.4 | 33.1 | |
| 34 | J-2 | 46.9 | 34.6 | 36.1 | 35.7 | |
| 35 | J-3 | 46.4 | 33.2 | 35.1 | 34.1 | |
| 36 | J-4 | 48.5 | 33.0 | 34.3 | 34.7 | |
| 37 | J-5 | 49.9 | 33.9 | 35.4 | 34.7 | |
| 38 | J-10 | | 31.5 | 31.4 | 31.6 | |
| 39 | J-11 | ' | 31.9 | 31.4 | 29.7 | |
| 40 | J-18 | 45.7 | 31.2 | 32.8 | 32.9 | |
| 41 | J-19 | 46.8 | 30.8 | 32.2 | 33.0 | |
| 42 | J-20 | 43.6 | 31.3 | 31.5 | 32.2 | |
| 43 | J-21 | 41.2 | 31.0 | 31.4 | 30.5 | |
| 44 | J-22 | 42.1 | 29.8 | 30.2 | 29.8 | |

Page 19

BAG WEIGHT SURVEYS FOR COMPARTMENT B2, UNIT 2

| Bag Weigh n pounds | | Before using Sonic Horns | While using Sonic Horns | | | |
|-----------------------|-----------------|-----------------------------|-------------------------|-----------|---------|--|
| | Date | 2/4/91 | 4/30/91 | 7/15/91 | 9/24/91 | |
| | Bag Location | – – , ,,,,,, | ",55,5" | 1,,,,,,,, | | |
| 45 | K-4 | <u> </u> | 33.8 | 34.0 | 33.0 | |
| 46 | K-10 | | 33.2 | 34.2 | 34.8 | |
| 47 | K-18 | | | 34.1 | 37.4 | |
| 48 | K-19 | | | 32.1 | 33.4 | |
| 49 | L-18 | | | 36.5 | 34.4 | |
| 50 | L-19 | | | 34.4 | 33.7 | |
| 51 | M-12 | | 33.4 | 33.0 | 33.3 | |
| 52 | M-13 | | 33.2 | 33.5 | 34.5 | |
| 53 | N-12 | | | 38.6 | 34.9 | |
| 54 | N-13 | | | 36.0 | 34.5 | |
| 55 | 0-12 | | | 35.2 | 35.0 | |
| 56 | 0-13 | | | 34.2 | 35.6 | |
| 57 | 0-14 | | | 36.5 | 35.3 | |
| 58 | 0-15 | | 33.8 | 34.8 | 34.0 | |
| 59 | P-1 | | | 32.0 | 33.5 | |
| 60 | P-4 | 47.8 | 35.1 | 36.1 | 39.6 | |
| 61 | P-5 | 50.7 | 34.2 | 36.1 | 36.2 | |
| 62 | P-6 | 51.4 | 33.5 | 35.6 | 36.7 | |
| 63 | P-7 | 48.0 | 32.7 | 34.4 | 36.9 | |
| 64 | P-12 | 49.5 | 33.1 | 34.3 | 35.6 | |
| 65 | P-15 | | | 36.4 | 35.2 | |
| 66 | P-21 | | | 31.9 | 32.8 | |
| 67 | P-22 | 40.0 | 32.1 | 32.2 | 33.2 | |
| 68 | Q-1 | | | 36.4 | 37.6 | |
| 69 | Q-12 | 48.8 | 35.4 | 37.7 | 37.9 | |
| 70 | Q-21 | | | 33.9 | 34.7 | |
| 71 | Q-22 | 44.5 | 33.5 | 31.9 | 35.2 | |
| 72 | R-1 | | | 34.6 | 33.4 | |
| 73 | R-12 | 41.2 | 33.1 | 33.8 | 32.9 | |
| 74 | R-21 | | | 30.8 | 32.9 | |
| 75 | R-22 | 42.5 | 32.2 | 33.1 | 31.2 | |
| | Average Bag | | | <u> </u> | | |
| | Weight, Ibs. | 45.4 | 31.7 | 32.7 | 32.6 | |
| | | | 1 0 | | | |
| | Standard | | | | | |
| | Deviation, lbs. | 3.2 | 1.9 | 2.8 | 3.0 | |
| | Number of | <u> </u> | | 1 | I | |
| | Bags Weighed | 40 | 52 | 75 | 75 | |

sonic-horn-assisted reverse-gas cleaning average out to be 32.3 lbs. The use of sonic horns during cleaning reduced the weight of the bags a conservative 13 lbs. Table 2 shows the tabulated bag weight data for Compartment B4. The lowest average bag weight calculated was 48.3 lbs which is 16 lbs more than the average bag weight in Compartment B2 while using sonic horns.

The bag weight survey done for Compartment B4 on July 15, 1991 was accidently destroyed before it was tabulated or copied but all of the bags weighed had similar weights to those tabulated.

During the bag weight surveys, a test was done to see the difference between bag weights before and after hand shaking the bags. It was noted that the sonic horn cleaned bags in Compartment B2 would lose about 3 to 5 additional pounds when they were shook by hand but, the bags in Compartment B4 would lose 13 to 15 pounds by hand shaking them. The sonic horns seem to provide much of the cleaning that can be accomplished by a vigorous hand shaking.

Higher Permeability shown in a Laboratory Tested Baq

Before using the sonic horns, two bags were taken from both Compartments B2 and B4 to be sent to testing laboratories. Bags I-10 and M-13 were taken from Compartment B2 and bags I-4 and 0-20 were taken from Compartment B4. After completing the sonic horn testing another two bags were taken from each of the compartments. Bags J-11 and P-15 were taken from Compartment B2 and D-18 and I-8 were taken from Compartment B4 on July 15, 1991.

The bags were sent to two bag testing facilities along with bags from the annual bag testing program. Bags M-13 and J-11 from Compartment B2 and bags O-20 and P-18 from Compartment B4 were sent to Environmental Consultant Company (ECC). Bags I-10 and P-15 from Compartment B2 and bags I-4 and I-8 from Compartment B4 were sent to Grubb Filtration Testing Services, Incorporated (GFTS).

The bag testing results from both ECC and GFTS are included in Appendix H.

The testing laboratories were asked to run the normal tests on these sonic-horn test bags but of particular interest was the "as-received" permeabilities and also the inspections to see if any damage could be seen from the use of the sonic horns.

ECC reported a substantial increase in the "as-received" permeability in Bag J-11, after using sonic horns bag, and included a picture showing a reduction of embedded dust in this bag. The average of the three "as-received" permeabilities for Bag J-11 was 2.32 ft³/min/ft² at 0.5 inH₂O compared to 1.8 ft³/min/ft² at 0.5 inH₂O for Bag M-13. The increase in "as-received" permeability after using the sonic horns was 28.7%.

BAG WEIGHT SURVEYS FOR COMPARTMENT B4, UNIT 2

| Bag Weight | | Before using | | Sonic Horns | |
|-----------------|--------------|--------------|----------------|---|---------|
| in pounds, lbs. | | Sonic Horns | Compartment BZ | | |
| 1 | Date | 2/4/91 | 4/30/91 | 7/15/91 | 9/24/91 |
| | Bag Location | | | | |
| 1 | A-1 | 46.8 | 59.9 | | 45.8 |
| 2 | A-12 | 47.3 | 55.4 | | 49.0 |
| 3 | A-21 | | | | 46.9 |
| 4 | B-1 | 49.2 | 52.9 | | 49.4 |
| 5 | B-12 | 53.7 | 55.3 | | 53.6 |
| 6 | B-21 | | | | 46.5 |
| 7 | C-1 | 58.8 | 61.2 | | 55.4 |
| 8 | C-12 | 52.4 | 62.1 | | 51.9 |
| 9 | C-21 | | | | 49.8 |
| 10 | D-1 | 47.9 | 53.5 | | 46.7 |
| 11 | D-2 | | | | 38.4 |
| 12 | D-3 | | | | 43.0 |
| 13 | D-4 | | 53.7 | | 47.3 |
| 14 | D-11 | 50.0 | 53.1 | | 50.8 |
| 15 | D-16 | 39.9 | 55.6 | | 53.2 |
| 16 | D-17 | 51.2 | 56.9 | | 49.6 |
| 17 | D-18 | 48.6 | 55.9 | | 50.6 |
| 18 | D-19 | 48.2 | 52.0 | | 48.4 |
| 19 | D-20 | | 50.3 | | 46.2 |
| 20 | E-1 | | | | 49.9 |
| 21 | E-11 | 52.7 | 50.0 | | 51.6 |
| 22 | E-16 | 48.7 | 57.1 | | 55.3 |
| 23 | E-17 | 47.9 | 56.4 | | 53.0 |
| 24 | E-18 | 48.1 | 52.8 | | 51.8 |
| 25 | E-19 | | 55.0 | | 48.3 |
| 26 | E-20 | | 55.0 | | 49.2 |
| 27 | F-1 | | | | 49.6 |
| 28 | F-11 | 45.4 | 51.9 | | 51.0 |
| 29 | G-11 | 39.9 | 55.3 | | 46.7 |
| 30 | H-11 | 49.7 | 52.5 | | 56.7 |
| 31 | 1-4 | 51.3 | 37.8 | | 39.2 |
| 32 | J-11 | 52.9 | 54.6 | | 50.2 |
| 33 | J-1 | 47.1 | 51.1 | *************************************** | 40.7 |
| 34 | J-2 | 49.0 | 53.4 | | 48.9 |
| 35 | J-3 | 50.1 | 58.1 | | 51.1 |
| 36 | J-4 | 50.5 | 54.0 | | 48.3 |
| 37 | J-5 | 52.5 | 57.9 | <u> </u> | 52.5 |
| 38 | J-10 | 1 32.3 | 60.0 | | 59.8 |
| 39 | J-11 | + | 56.3 | | 48.0 |
| 40 | J-18 | 53.9 | 53.0 | | 45.4 |
| 41 | J-19 | 56.3 | 55.1 | | 50.3 |
| 42 | J-20 | 43.2 | 53.4 | | 46.4 |
| 43 | J-21 | 49.7 | 50.5 | | 46.7 |
| 44 | J-21 | | | | |
| 44 | J-22 | 46.4 | 43.0 | | 43.3 |

BAG WEIGHT SURVEYS FOR COMPARTMENT B4, UNIT 2

| Bag Weights are | | Before using | | While using Sonic Horns in | | | | |
|-----------------|-----------------|--------------|---------|----------------------------|---------|--|--|--|
| in pounds, lbs. | | Sonic Horns | | ment BZ | | | | |
| | Date | 2/4/91 | 4/30/91 | 7/15/91 | 9/24/91 | | | |
| | Bag Location | | | | | | | |
| 45 | K-4 | | 53.9 | | 51.8 | | | |
| 46 | K-10 | | 52.0 | | 61.9 | | | |
| 47 | K-18 | | | | 54.2 | | | |
| 48 | K-19 | | | | 48.2 | | | |
| 49 | L-18 | | | | 48.1 | | | |
| 50 | L-19 | | | | 50.4 | | | |
| 51 | M-12 | | | | 41.4 | | | |
| 52 | M-13 | | | | 54.0 | | | |
| 53 | N-12 | | | | 54.3 | | | |
| 54 | N-13 | | | | 51.5 | | | |
| 55 | 0-12 | | | | 51.3 | | | |
| 56 | 0-13 | | | | 51.9 | | | |
| 57 | 0-14 | | | | 54.4 | | | |
| 58 | 0-15 | | 54.8 | | 49.2 | | | |
| 59 | 0-20 | 53.2 | 37.9 | | 40.4 | | | |
| 60 | P-1 | | | | 41.8 | | | |
| 61 | P-4 | 67.3 | 56.0 | | 47.8 | | | |
| 62 | P-5 | 52.8 | 53.4 | | 48.1 | | | |
| 63 | P-6 | 56.3 | 56.5 | | 55.8 | | | |
| 64 | P-7 | 56.2 | 53.0 | | 53.9 | | | |
| 65 | P-12 | 55.1 | 56.6 | | 52.1 | | | |
| 66 | P-21 | | | | 42.6 | | | |
| 67 | P-22 | 49.1 | 47.8 | | 42.1 | | | |
| 68 | Q-1 | | | | 42.0 | | | |
| 69 | Q-12 | 56.2 | 52.0 | | 48.2 | | | |
| 70 | Q-21 | | | | 43.8 | | | |
| 71 | Q-22 | 52.2 | 49.6 | | 38.9 | | | |
| 72 | R-1 | | | | 41.1 | | | |
| 73 | R-12 | 38.9 | 44.9 | | 36.5 | | | |
| 74 | R-21 | | | | 37.8 | | | |
| 75 | R-22 | 42.9 | 42.5 | | 33.8 | | | |
| | _ | | 1 | I | | | | |
| | Average Bag | | | | | | | |
| | Weight, lbs. | 50.2 | 53.2 | | 48.3 | | | |
| | Standard | | -T | | | | | |
| | Standard | | 1 | | | | | |
| | Deviation, lbs. | 5.3 | 5.0 | | 5.4 | | | |
| | Number of | | | | | | | |
| | 1 | 42 | F1 | | 75 | | | |
| | Bags Weighed | 42 | 51 | | 75 | | | |

GFTS reported a slight decrease in "as-received" permeability of the sonic horn cleaned bag (P-15); therefore, there is still some question about being able to see increased permeabilities from sonic horns in laboratory tested bags.

The strengths and condition of the bags tested were excellent and there is no apparent damage from the use of sonic horns.

Three BHA Group, Inc.'s AH-25 Sonic Horns Provide Good Sound Pressure Levels

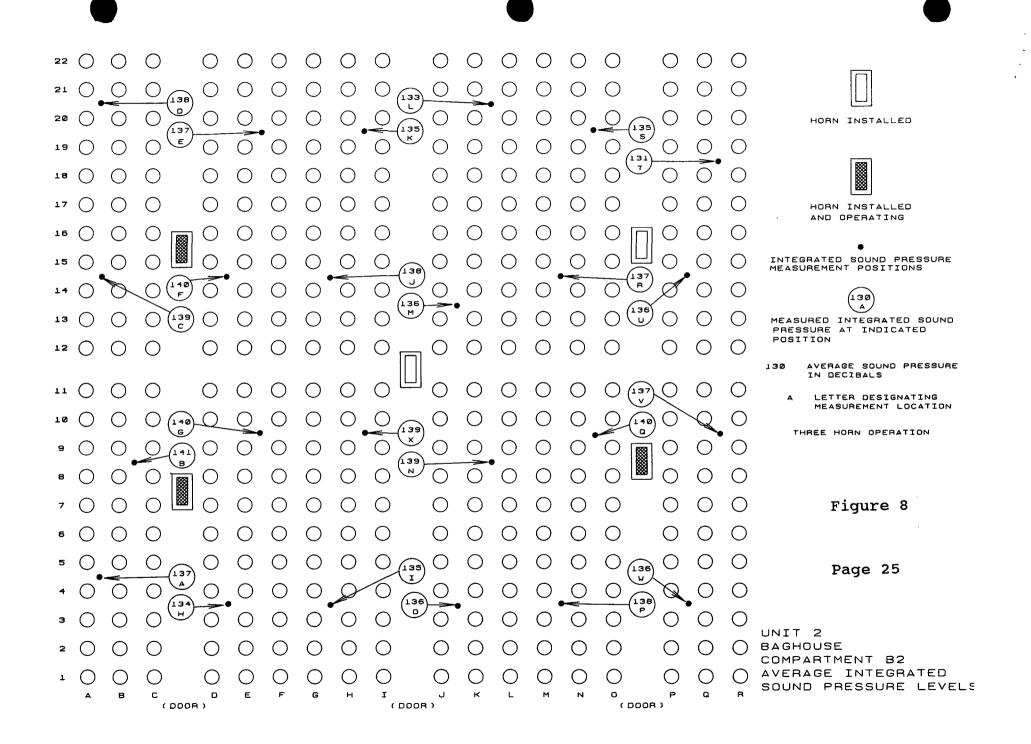
Sound pressure level testing was done in Compartment B2 to determine the number of horns that were required to get good uniform sound distribution and to check that recommended sound pressure levels were being provided.

Five BHA AH-25 sonic horns had been installed in Compartment B2 with two horns in the south aisle at 1/3 and 2/3 of the way back, one horn in the middle of the middle aisle and two horns in the north aisle at 1/3 and 2/3 of the way back. Unfortunately, the only three horns that were working when it came time to do the testing were the two horns in the south aisle and the horn 1/3 of the way back in the north aisle. Maintenance was unavailable to repair or move the horns to meet my timetable so the sound pressure level testing was done with the three sonic horns that were working, even though they were in a poor orientation for good uniform sound distribution.

Four noise dosimeters were tied to a rope and set to record the peak sound pressure level in decibels. Then in 24 locations in Compartment B2 a vertical traverse of integrated sound pressure levels was recorded. Values for integrated sound pressure levels were recorded at one foot elevations from the tube sheet to one foot above the filter bag caps.

The integrated sound pressure levels measured at each foot of the 24 vertical traverses are included in Appendix F. These values were then tabulated and changed to units of Pascal and then averaged for the vertical traverse. The average sound pressure level in Pascals was then converted back to decibels. Figure 8 shows the filter bag layout, the locations of the sonic horns, the location of the sonic horns that were working for this test, the location and letter designation for each vertical traverse and the average integrated sound pressure level for each vertical traverse in decibels.

EPRI recommends that the integrated sound pressure level output of sonic horns for low-sulfur coal be at least 80 Pa or about 132 dB. BHA recommends that the integrated sound pressure level outputs be at least 135 dB. Figure 8 shows that only three of the 24 vertical traverses have levels below 135 dB and only one of those



is below EPRI's recommendation of 132 dB. Three BHA AH-25 sonic horns meet the recommendations for integrated sound pressure levels.

Calculation of Predicted Compartment Differential Pressure

Table 3 is three pages of calculations that show that a $2.0~{\rm in}H_2O$ pressure drop is certainly attainable if sonic horns are installed in every compartment in the baghouse. The numbers used in the calculations are conservative. Tabulated data and additional plots of information on the same day used for these calculations are included in Appendix G.



| PROJECT NO. | | | w | 0 NO. | 91- | .97 | 693 | -00 | PAGE | : <u> </u> | OF | 3_ | _ |
|-------------|-------|----|-------|-------|------|-----|-----|---------|------|------------|----|--------|---|
| ORIGINATED | BY JE | FF | PAYNE | | DATE | | | CHECKED | BY | | | DATE _ | |
| | | | | | | ^ | 1 1 | 1. | _ | | | | |

DESCRIPTION Sonic Horn lest Calculations

Compartment or tubesheet differential pressure can be calculated as follows:

$$\Delta P = Q * S$$

(Equation 1)

where

DP - tubesheet or compartment differential pressure, in 420

Q - volumetric flow rate, ft3/min
S - fabric drag, in H2O/ft/min
A - surface area of filter cloth material, ft2
Q/A - gas to cloth ratio which is a Key design
parameter for fabric filters, ft/min.

Assign subscripts for before and after sonic horn assisted cleaning as follows:

1 = before sonic horns 2 = after sonic horns

$$\Delta P_1 = \frac{Q_1 * S_1}{A}$$

(Equation 2)

$$\Delta P_2 = \frac{Q_2 * S_2}{A}$$

(Equation 3)

The surface area of filter cloth material, A, is a constant and does not change because of sonic horn assisted cleaning,

Dividing Equation 2 by Equation 3 and solving for Sz yields the following

$$S_2 = \frac{\Delta P_2 \left(Q_1 * S_1\right)}{\Delta P_1 * Q_2}$$
 (Equation 4)

Solving for Q1 in Equation 2 yields

$$Q_1 = \frac{\Delta P_1 * A}{5_1}$$
 (Equation 5)



DESCRIPTION Soric Horn Test Calculations

What we really want to know is the new differential pressure for the situation of normal volumetric flow rate with the reduced dra tabric drag which should result from sonic assisted cleaning of the bags. The equation of interest is then

$$\Delta P_{\text{new}} = \frac{Q_1 * S_2}{A}$$
 (Equation 6)

where

Q, - is the normal volumetric flow rate for equal drag distribution that was measured before sonic horn assisted cleaning, ft3/min

52- fabric drag after sonic assisted cleaning.

Substitute Equation 4 for 5z and Equation 5 for Q_1 to get the following

$$\Delta P_{\text{new}} = \left(\frac{\Delta P_1 * A}{S}\right) * \frac{\Delta P_2(Q_1 * S_1)}{\Delta P_1 * Q_2} = \Delta P_2 * \left(\frac{Q_1}{Q_2}\right)$$
(Equation 7)

Equation 7 will be used to calculate the new differential Pressure for a compartment operating in a baghouse where all compartments have sonic horns installed in them to assist with cleaning.



PROJECT NO. ______ WO NO. 91-97693-00 PAGE 3 OF 3

ORIGINATED BY JEFF PAYNE DATE ______ CHECKED BY ______ DATE ______

DESCRIPTION Sonic Horn Test Calculations

The sonic horns that were installed in Unit Z's compartment B2 were BHA Group, Inc. 's AH-25 horns.

The sonic horns were first used during a cleaning Cycle on April 10, 1991 at 11:09:20 thru

As shown on the attached graphs and computer printouts, average compartment BZ tubesheet ΔP , as recorded for IBFM's 6,7,8,9 and 10, during the period from 9:07 to 11:00 is conservatively approximately 6.40 intto. $\Delta P_1 \cong 6.40$ intto. To be every more conservative and try to get the differential pressure just after cleaning I will use $\Delta P_1 \cong 6.0$ intto.

As shown on the attached graphs and computer printouts, average compartment B2 tubesheet DP, as recorded for IBFM 6, during sonic horn assisted cleaning and just after cleaning is conservatively \$.25 in H2O. DP2 = 5.25 th H2O.

Gas to Cloth ratios, (G/C, ft/min), will be used to calculate the ratio of volumetric flow rates.

GIC (f/min) before horns is approximately 1.80 ft/min. Q1/A = 1.80 ft/min.

G/C (ft/min) after horns is approximately 2.55 ft/min. $Q_2/A = 2.55$ ft/min

Substituting these values into Equation 7 gives the following:

$$\Delta P_{\text{new}} = 5.25 \text{ m H}_20 * \left(\frac{1.80 \text{ ft/min}}{2.55 \text{ ft/min}}\right) = 3.71 \text{ in H}_20$$

 $\Delta P_1 - \Delta P_{\text{new}} = 6.0 \text{ in H}_20 - 3.7 \text{ in H}_20 = 2.3 \text{ in H}_20$

An overall reduction of 2.3 in H2O in differential pressure is calculated.

VI. Economic Justification

The Benefit/Cost Ratio for this project is 1.83 and the project Payback Period is 8.7 years. This was calculated using the following:

- The benefit from the project is a 1.5 inH₂O reduction in casing differential pressure which reduces the power input to the ID fans. The savings due to the ID fan power reduction is \$189,000.00 per year.
- The cost of the project was estimated to be \$1,440,000.00. This total cost includes \$720,000.00 for installation labor, \$700,000.00 for material and \$20,000 for engineering labor.
- The cost for operation and maintenance is estimated to be \$24,000.00 per year.
- The life of the project is taken as 30 years.
- The cost of money is 8.5% and the inflation rate is 4.0%.

There is also a significant possibility that this project will increase the life of the filter bags. If, because of the installation of sonic horns, the filter bags had a nine year life instead of an eight year life an additional \$500,000.00 savings would result.

Benefit Analysis

A conservative 2.0 inH $_2$ O differential pressure drop reduction was calculated in the last section. The life of the project is 30 years so there will be a few times that the filter bags will be replaced. New filter bags will not need a differential pressure drop reduction for a limited time period; therefore, a differential pressure drop of 1.5 inH $_2$ O will be used for the economic benefit calculation.

A test was run on Unit 1 on May 4, 1990 to measure the increased power required for the ID Fans when the casing differential pressure increases. Unit 1's baghouse was operating with all compartments in service except for the compartments that were cleaning. This operation provides for the smallest casing differential pressure drop. While maintaining these operating conditions, data from the ID Fans and casing differential pressures were recorded. Then, two compartments per casing were taken out of service with a third compartment cleaning. Data from the ID Fans and the casing differential pressure were again recorded.

The average casing differential pressure for the first part of the test was 6.92 inH₂O and the average total power consumption of the ID Fans was 8.378 MW. The average casing differential pressure for the second part of the test was 8.03 inH₂O and the average total power consumption of the ID Fans was 9.162 MW. These data show a 784 KW power increase input to the ID Fans for a 1.1 inH₂O difference in the casing differential pressure; this is 712 KW/inH₂O.

For a station availability of 94.71% and a net output factor of 97.05%, the additional auxiliary power requirements for one year for an additional inch of water pressure drop across the baghouse would be 5,739 MWH. In a letter from Mr. Bruce E. Blowey to Mr. S. Gale Chapman dated May 23, 1989 (included in Appendix A), we were instructed that any improvement which decreases auxiliary power usage and therefore increases net generation should be assumed to result in savings of 1.1 cents per kwh (variable fuel cost). Using this value, the cost of running one units baghouse at an additional inch of water average casing differential pressure drop across all three casings is \$63,126.00.

The benefit from a 1.5 in H_2O casing differential pressure reduction on both units is a savings of input power to the ID fans of \$189,000.00.

In Mr. Blowey's letter, mentioned above, he states that "the 1.1 cents per kwh is a very conservative approach to what the Purchasers otherwise spend to generate that extra kwh."

Jim Carnevale of LADWP and Stan Smith authored an EPRI First Use article (included in Appendix A) in which they reported that a 0.7 inH2O reduction of differential pressure would result in a savings of \$105,000 per year. They assumed that a pressure drop of 1.0 inH2O costs \$150,000 per year in replacement power. The biggest difference in these numbers reported is probably the assumed cost of power.

Its obvious that the benefit of decreased casing differential pressure drop is extremely sensitive to the assumed cost of auxiliary power. If we used a larger cost for auxiliary power, the savings of power to run the ID Fans would be more beneficial.

Cost Analysis

The cost estimate for this project was made using numbers estimated by GEESI. In a letter from Edward Wollyung of GEESI to R. W. Dotton of Black and Veatch, dated November 9, 1983 (included in Appendix A), GEESI gives a budgetary estimate for the installation of sonic horns based on their experience at BG&E.

Material costs were estimated to be \$700,000.00. If BHA's Model AH-25 sonic horns were installed, we know that three horns per compartment would do the job. This would require 288 sonic horns to complete installation in both units. BHA in a letter dated June 25, 1991 (included in Appendix A) gave a budgetary price for three sonic horns per compartment and horn accessories of \$1580.00 per horn. The cost of the 288 sonic horns and accessories is \$455,040.00. The estimate given by GEESI is for one baghouse and they estimated 4 horns per compartment. GEESI estimated the cost of three air compressors, three air dryers, three prefilters and three air receivers as \$37,000.00 in 1983 dollars. GEESI estimated the cost of piping to be \$80,000.00 in 1983 dollars. To update these estimates to 1992 dollars these numbers were increased 30%. The air system for the sonic horns is then estimated to cost \$48,000.00 and the piping for the system will cost \$104,000.00 per unit.

The total estimated cost for material is \$759,000.00. This is more than put into the budget because the cost of the sonic horns were expected to be less when the budget justification was due.

The estimated cost for installation labor is \$720,000.00. GEESI estimated that installation labor would be \$280,000.00 per unit in 1983 dollars. This number increased by 28.6% is \$360,000.00 per unit or \$720,000.00 for the project.

The cost of engineering labor was estimated to be \$20,000.00.

The cost of operation and maintenance was estimated to be \$24,000.00 per year. This includes 80 hours of work on the compressors a year, replacing 1/4 of the sonic horn diaphragms each year at a cost of \$180.00 per diaphragm kit and allowing 5 hours of mechanical labor to replace the diaphragms. The cost of mechanical labor was assumed to be \$25.00 per hour. The above numbers represent the replacement of 72 diaphragms at a material cost of \$12,960.00 in 360 hours which represents \$9000.00 of labor. The 80 hours of work on the compressors represents \$2000.00 per year. There is no set time that diaphragms need to be replaced and the manufacturer believes that they will last much longer than 4 years but this was felt to be a conservative estimate for maintenance.

The numbers used to calculate the benefit/cost ratio and the payback period were a benefit of \$165,000.00 per year over the 30 year life of the project, which is the power savings of \$189,000.00 per year minus the operation and maintenance costs of \$24,000.00 per year, and the total project cost of \$1,440,000.00. The cost of money was taken as 8.5% and the inflation rate is 4%.

There could be some concern over the fact that with the numbers used in this estimation it appears the material costs are \$60,000.00 short of what they should be. If the total project cost is increased to \$1,500,000.00, the benefit/cost ratio is 1.76 and the payback period is 9.1 years. Also, BHA Group, Inc. is providing an estimate for the total project cost which includes their horns, air compressors, piping and installation and their preliminary estimate was \$1,040,000.00. The numbers used are a good indication of the economic viability of the project.

Appendix A

Cost Estimation Reference Materials

CAPITAL PROJECT JUSTIFICATION 1992-1993

<u>JOB NO:</u> IGS92- WO.#91-97693-00

TITLE: Sonic Horns in Baghouse

DESCRIPTION:

Sonic horns will be installed in each compartment in the baghouse. A separate air supply will be installed which consists of three systems each including a compressor, dryer, prefilter, receiver and the

associated piping. The sonic horns will assist reverse gas cleaning by sounding 10 seconds during the 30 seconds that reverse gas blows through

DRAFT

the filter bags.

JUSTIFICATION: Since 1984, 17 of 50 utility boiler baghouses operating with reverse gas cleaning have retrofitted sonic horns. The reported improvement in differential pressure from the use of sonic assisted cleaning ranges

from 1 to 3 inH₂O.

Tests conducted during this last year have proven that the sonic horns are effective in cleaning the fabric bags better; thereby, reducing the residual dust cake, increasing the permeability of the bags and reducing the differential pressure.

Compartment B2 on Unit 2 had sonic horns installed for testing. The tests show that the bag weights after sonic assisted cleaning were reduced by 13 lbs. The sonic assisted cleaning of the bags also showed 29% higher permeability in bags sent to a testing laboratory and flow rates approximately 40% higher through Compartment B2. The results of the testing show that a 2 inH2O reduction in casing differential pressure should be seen by installation of horns in all compartments.

The 2 inH₂O differential pressure reduction is true for our used filter bags but will not be realized for new fabric filter bags. To account for this the economic justification will be based on a casing differential pressure reduction of 1.5 inH₂O.



In a test on Unit 1 in 1990, it was determined that a 1.0 in $\rm H_2O$ decrease in differential pressure across the baghouse resulted in an annual savings of input power to the induced draft fans of \$63,000.00 per unit. This savings was calculated using a power reduction of 712 KW/in $\rm H_2O$, a station availability of 94.71%, a net output factor of 97.05% and a cost savings of 1.1 cents per kwh(variable fuel cost).

The cost of the project is estimated to be \$1,440,000.00. The cost for operation and maintenance is estimated to be \$24,000.00 per year. The expected savings per year due to the 1.5 inH₂O casing differential pressure reduction will be \$189,000.00 per year. The life of the project is taken as 30 years, cost of money is 8.5% and the inflation rate is 4.0%. The Benefit/Cost Ratio for this project is 1.83 and the project Payback Period is 8.7 years.

This project is also expected to increase our bag life. While just how much is difficult to quantify, if because of the sonic horns we are able to use our existing bags 9 years instead of an estimated 8 years the cost saving would be nearly another \$500,000.00. Our bags have been tested and are in excellent shape. The only problem right now is low bag permeability and the sonic horns will improve bag permeability.

COST ESTIMATE:

Engineering Labor \$ 20,000 Installation Labor \$ 720,000 Material \$ 700,000

Job Total \$1,440,000

ALTERNATIVES:

The only alternative is to remain with reverse gas cleaning only; this would result in premature filter bag replacement and increased power usage by the I.D. fans because of high differential pressures.

SCHEDULE:

Complete before June 30, 1993.

DEFERRABILITY:

Yes, but the filter bags may need to be replaced if this project is deferred.

Department of Water and Power



TOM BRADLEY Mayor Commission RICK J CARUSO, President JACK W LEENEY, Vice President ANGEL M ECHEVARRIA CAROL WHEELER WALTER A. ZELMAN JUDITH K, DAYISON, Secretary

NORMAN E. NICHOLS, General Manager and Chief Engineer
ELDON A. COTTON, Assistant General Manager - Power
DUANE L. GEORGESON, Assistant General Manager - Water
DANIEL W. WATERS, Assistant General Manager - External Affairs
NORMAN J. POWERS, Chief Financial Officer

July 17, 188

Mr. S. Gale Chapman President and Chief Operations Officer Intermountain Power Service Corporation Route 1, Box 864 Delta, Utah 84624

RECEIVED

JIII 19 1989

Dear Mr. Chapman:

"TECHNICAL SERVICES"

Meeting on Capital Expenditures
May 23, 1989

On May 23, 1989, a meeting of IPSC staff was held at the plant site regarding capital expenditures which was attended by Messrs. Neil Boothe and Cesar Pablo from the Department. A number of issues were raised requiring further clarification. This letter finalizes the information provided in a draft telecopied on June 8, 1989 and referred to in your letter dated June 21, 1989.

Replacement of Equipment (no upgrade)

Pending the establishment of a Retirement Unit Catalogue (scheduled in 1990), the replacement (not repair) of any single piece of equipment with a value of \$50,000 or greater shall be considered a capital expenditure whether or not the replacement is done in conjunction with a maintenance job, overhaul, or other circumstance. This means that total costs of such removals and replacements must be charged to separate work orders coded to the appropriate capital accounts. The \$50,000 limit pertains to equipment which is part of major "systems" such as those defined by Black & Veatch System This does not pertain to stand alone equipment like furniture, computer equipment, vehicles, test equipment, tools, etc. The purchase of the latter kinds of equipment is capitalized if greater than \$500. See Budget and Cost Control Procedure 200-10.

Capital Spares

Spare parts purchased for inventory, including both new capital spares and/or replacements for original capital spares in service, are to be capitalized if the value is \$50,000 or greater. This will require the coordination of Warehouse, Maintenance Planning, Accounting, and Technical Services.

Use of Depreciation in Cost/Benefit Analyses

Calculations of depreciation are <u>not</u> to be used when analyzing alternatives in conjunction with cost/benefit analyses. Depreciation is not a consideration since there are no significant tax consequences involved. However the useful life of equipment always needs to be considered when analyzing present values of alternatives.

Assumption for Reducing Auxiliary Power Usage

Any improvement which decreases auxiliary power usage and therefore <u>increases</u> net generation should be assumed to result in a savings of 1.1 cents per kwh (variable fuel cost). This is a conservative approach to estimating what the Purchasers would otherwise spend to generate that extra kwh. Also, see the comments below pertaining to replacement energy.

Assumption for Replacement Energy Value

When preparing cost/benefit analyses to justify certain capital expenditures, a value may sometimes be assumed for reducing outage time on a unit. The benefit is presumed to be the foregoing of additional cost to Purchasers for replacement energy less the savings related to not producing the same amount at Intermountain Generating Station (IGS).

The amount of \$22,000 per hour per unit was previously provided to IPSC in my letter dated January 4, 1989 based on study by Department Engineers of alternate sources. However, this amount did not consider the savings associated with not burning the coal at IGS. A more realistic amount for "extra expense" would be:

\$55,541,000 $.67 \div 8,760 = $9,460/hr per unit$ Revised Estimate LAHours Average net of "extra "savings" for Share per expense for LA of year reducing outage time per unit for energy one year

Charging Engineering Costs Directly to IPSC Capital Work Orders

To the extent practical, engineering costs should be charged to the work order benefited. Engineering costs are part of total costs of additions and betterments, and it is useful to accumulate all costs against the job. I will leave the interpretation as to what is "practical" to IPSC. To the extent IPSC engineering is not charged directly, it will be allocated in accordance with existing accounting procedures.

The above comments are intended to clarify several issues related to capital expenditures. If there are questions, Mr. D. N. Boothe may be contacted at (213) 481-4190.

Sincerely,

BRUCE E. BLOWEY

Engineer of Generation - External

c: Messrs. Robert A. Davis (IPSC)
Joe D. Hamblin "
Dennis K. Killian "
Neil H. Clay "
Norman A. Mincer "

D. N. Boothe

JLP Jerry Hintze

Department of Water and Power



the City of Los Angeles

TOM BRADLEY Mayor Commission
MICHAEL J. GAGE, President
RICK J. CARUSO, Vice President
ANGEL M. ECHEVARRIA
DOROTHY GREEN
MARY D. NICHOLS
JUDITH K. DAVISON, Secretary

DANIEL W. WATERS, General Manager and Chief Engineer ELDON A. COTTON, Assistant General Manager - Power JAMES F. WICKSER, Assistant General Manager - Water NORMAN L. BUEHRING, Assistant General Manager - External Affairs NORMAN J. POWERS, Chief Financial Officer

August 26, 1991

CC: GROUP

Mr. S. Gale Chapman President and Chief Operations Officer Intermountain Power Service Corporation Route 1, Box 864 Delta, Utah 84624

Dear Mr. Chapman:

Preliminary 1992-93 Budget Estimates

Please submit your preliminary budget estimates for Fiscal Year 1992-93 in summary form no later than September 30, 1991. These estimates will be incorporated in the total IPF Operating Budget transmitted to the Coordinating Committee by the Operating Agent.

An updated organizational chart, total IPSC budget summary, summary pages for each Department budget, and summary capital expenditures comprise the level of detail required at this time with the format being the same as provided for the summary pages of the 1991-92 budget. No detailed backup is required for the preliminary submittal.

Please observe the following guidelines in preparing your estimates:

- 1. Personnel levels should be no higher than current approved levels and reductions through attrition should be considered where feasible and prudent considering operating needs.
- 2. Although only summary costs for capital expenditures are required by September 30, 1991, IPSC needs to continue working with PD&C to develop coordinated cost estimates for capital projects and to determine the appropriate lead responsibilities and design review requirements for the various jobs.

 For economic analysis, assume cost of money is 8.5 percent, extra cost of a one unit lost IGS generation is \$10,000 per hour, and a marginal fuel cost of \$1,200 per hour.

111 North Hope Street, Los Angeles, California Mailing address: Box 111, Los Angeles 90051-0100

Telephone: (213) 481-4211 Cable address: DI WAPOLA F.A.Y. (213) 481-8701

3. The latest approved outage schedule for 1992-93 is assumed with ten weeks of scheduled unit outages. In addition, assume a 2-percent unscheduled outage rate. These assumptions should be incorporated into estimates for maintenance as well as items such as fuel oil, chemicals, limestone, etc.

MOTE!

4. An inflation rate of 4-percent should be assumed for labor, materials, and services unless better estimates are available.

Detailed budget information including justifications will be required by December 2, 1991, in the same format as the final 1991-92 IPSC Budget. If there are questions regarding the preliminary budget submittal due September 30, 1991, Mr. Daniel N. Boothe may be contacted at (213) 481-4190.

Sincerely,

Brue E. Blower

BRUCE E. BLOWEY
Assistant Engineer in Charge
of Operation and Maintenance

c: Mr. Dennis Killian

Mr. Neil H. Clay, IPSC

Mr. Sam W. Wardle, IPSC √

Mr. Daniel N. Boothe

Copy To Jerry Hintze 8/28/91



June 25, 1991

Baghouse Accessories
PrecipTech, Inc.
Filtra GmbH

Intermountain Power Service Route 1, Box 864 Delta, Utah 84624

ATTN: Mr. Jeff Payne

Dear Jeff:

The following is a budgetary quote for the acoustic horn system for your GEESI baghouse. It has been broken down into price per horn, which does include the following accessories:

3/4" Manual Isolation Air Valve

3/4" Stainless Steel Flex Hose

Chain Hanger Assembly

"Y" Strainer

1-1/2" Solenoid (one per compartment)

1-1/2" Manual Isolation Air Valve (one per compartment)

This quote is for budgetary purposes to be used in a payback analysis by Intermountain Power Service. This quote is based on outfitting one baghouse with three and four horns per compartment. The actual number of horns required will be determined when all testing is completed.

| Quantity Per Compartment | Description | Unit Price |
|-----------------------------|------------------------|------------|
| 3 | AH-25 with accessories | \$1,580.00 |
| 4 | AH-25 with accessories | \$1,540.00 |

BHA can provide a payback analysis based on the results from the current testing. We would require information on energy costs, differential pressure with and without horns, compressed air cost, etc.

Terms are net 30 days, F.O.B. Slater, Missouri.

8800 East 63rd Street • Kansas City, Missouri 64133-4883 (816) 356-8400 • FAX (816) 353-1873 • Telex 988098 SALES 800-821-2222 TO: Intermountain Power Service

DATE: June 25, 1991

PAGE: 2

After you have had the opportunity to review this information, I would like to discuss it with you. I can be reached at our Toll Free number, 1-800-821-2222.

Sincerely,

BHA GROUP, INC.

Andy Miller

Senior Sales Representative

AM: 12/IP4/BHAQ

cc: Mike Stinson, Systems Engineer

BHA Group, Inc.



GENERAL ELECTRIC

GENERAL ELECTRIC ENVIRONMENTAL SERVICES, INC. 200 NORTH SEVENTH STREET ● P.O. BOX 360 ● LEBANON, PENNSYLVANIA 17042 ● (717) 274-7000

November 9, 1983

Black & Veatch, Consulting Engineers P. O. Box 8405 11401 Lamar Street Kansas City, Missouri 64114

ATTENTION: Mr. R. W. Dutton

Dear Mr. Dutton:

REFERENCE: Intermountain Power Project

B&V: 9255-62,0203

GEESI: FF-29189/S.0.9203

IPP-820

SUBJECT: A.I.P. #FF-1000

Sonic Horns

Per the last A.I.P. Committee Meeting, GEESI was directed to provide budgetary cost information regarding the installation of sonic horns. Based on our experience at BG&E, GE is hereby submitting the following budgetary estimate:

| • | Engineering | I | \$ 18,000 |
|---|--|----------|----------------|
| • | Material | | • |
| | a. Manifold | | |
| | 1.) Horns (12) | x | \$ 16,000 |
| | 2.) Compressors (3) | = | \$ 20,000 |
| | 3.) Dryers (3) | = | \$ 12,000 |
| | 4.) Prefilters (3) | = | \$ 1,000 |
| | 5.) Receivers (3) | = | \$ 4,000 |
| | 6.) Piping | ± | \$ 6,500 |
| | b. Compartment | | 4 0,000 |
| | 1.) Horns (192) | = | \$250,000 |
| | 2.) Compressors (3) | = | \$ 20,000 |
| | 3.) Dryers (3) | = | \$ 12,000 |
| | 4.) Prefilters (3) | * | \$ 1,000 |
| | 5.) Receivers (3) | = | \$ 4,000 |
| | 6.) Piping | = | \$ 80,000 |
| | Total Material Price | * | \$426,500 |
| | NOTE: If plant air supply is sufficient, deduct receivers, and dryers. | compr | - |

receivers, and dryers.

Construction a. Manifold \$ 20,000 b. Compartments \$280,000 Total Construction Price \$300,000

Mr. R. W. Dutton November 9, 1983 Page Two

GEESI suggests that IPP install the Manifold System only as the benefits show in the previously presented test results—this to be the best return dollars spent. The budgetary cost* for manifold horns only is:

| | Engineering | Material | Construction | Tota1 |
|--------|-------------|-----------|--------------|-----------|
| Unit 1 | \$10,000 | \$ 40,000 | \$20,000 | \$ 70,000 |
| Unit 2 | <u> </u> | 40,000 | 20,000 | 60,000 |
| Total | \$10,000 | \$ 80,000 | \$40,000 | \$130,000 |

^{*}Costs do not include compressors.

Should you have any comments or questions regarding this matter, please call me. This estimate is based on current costs and is budgetary. If the project should seriously consider either full horn installation or the manifold approach, we would expect a Modification Proposal in order to give a firm estimate.

Very truly yours,

Edward R. Wollyung

Project Manager

ERW/vep

cc: G. Crameri

T. House

- T. Hoyne
- C. Kling
- D. Murdock
- M. Morris

EPRI

RP1129-8

December 1989 GENERATION

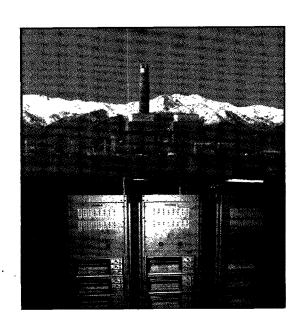
and proven utility because

EPRI MONITORING SYSTEM ENHANCES BAGHOUSE PERFORMANCE

"The EPRI-developed baghouse monitoring system contributed significantly to our high availability and low-pressure-drop operation."

James J Carnevale Los Angeles Dept of Water & Power

Stan Smith
Intermountain Power Service Corp.



PROBLEM Increasing numbers of utilities use fabric filters to control particulates in coal-fired power plants. Baghouses have an excellent record of controlling particulate emissions effectively in long-term rou-

tine operation. However, some baghouses have caused high operating costs, primarily because of high pressure drop and shorter-than-expected bag life.

SOLUTION Intermountain Power Service Corp. operates and maintains the Intermountain generating station on a day-to-day basis under the direction of the Los Angeles Dept. of Water & Power, the operating agent for the owner, Intermountain Power Association. To minimize pressure drop and extend bag life at the Intermountain station, the operator asked EPRI to sponsor a long-term testing program on its unit 1 baghouse. The goal was to detect and correct deficiencies quickly before the bags suffered any damage. EPRI developed a prototype baghouse performance monitoring system, which was installed before unit 1's initial startup. The system detected numerous problems, including bag failures, ash removal system deficiencies, and out-of-sequence damper operation. Correction of the problems improved baghouse operating characteristics significantly. Pressure drop was only 6.1 inches of water at 105% of maximum continuous rating (MCR), significantly lower than the guaranteed limits of 6.8 inches of water at 100% MCR.

In addition, EPRI analyzed bag precoating procedures, the effects of boiler operation on pressure drop and opacity, startup problems, fabric strength, bag weights and dustcake areal densities, coal and ash properties, and baghouse pressure drop and emissions. Engineers determined that the unit 1 baghouse could take advantage of the low fly ash cohesivity not only to reduce pressure drop, but also to extend bag life.

BENEFITS

- By reducing the pressure drop by 0.7 inches of water and extending bag life one year, Intermountain expects to save \$15.1 million during unit 1's 35-year life.
- The baghouse performance monitoring system and data analysis techniques can help utilities improve baghouse efficiency and reliability and overall plant operation.

FS8973B

Calculated Value of Los Angeles Dept. of Water & Power's Application

| | Invoctment | Estim | Estimated Saving (\$000) | | | |
|-----------|--|---------------------|-----------------------------|-------------------------------|--|--|
| Year | Investment Saving (\$000) ⁽¹⁾ | O&M ⁽²⁾ | Total | Present Value ³ | | |
| 1988–2022 | 5,645 | 9,484 | 15,129 | 3,542 | | |
| | Present v | value of tota sa | l estimated wing (\$000) | 3,542 | | |

saving (\$000)

35-year levelized annual saving (\$000)

319

Reference

 "Monitoring of Start-Up and Operation of Intermountain Power Project Unit #1 Fabric Filter." In Proceedings: Seventh Particulate Control Symposium, Vol. 2, EPRI GS-6208, February 1989.

EPRI reports are available from the Research Reports Center, (415) 965-4081.

Commercial Availability

Based on the success of this application, EPRI is developing an upgraded baghouse performance monitoring system. For information on its commercial availability, contact

Ramsey Chang Project Manager Electric Power Research Institute (415) 855-2535

For further information, contact: Electric Power Research Institute, P.O. Box 10412, Palo Alto, CA 94303 Walter Piulle, Project Manager, G&S Division, (415) 855-2470 George Offen, Program Manager, G&S Division, (415) 855-8942

Assumptions Used in Calculations

- 1. Investment saving is based on the assessment that careful attention to baghouse operation and performance can enhance bag life. Extending a bag's life one year beyond its threeyear guaranteed life can bring a capital saving of \$250,000 every four years, or an average annual saving of \$62,500 (1988 dollars).
- 2 O&M saving is based on the following:
 - · Full-load operating conditions are 900 MW, with a gas flow of 3.96 million actual cubic feet per minute (acfm), and an air-to-cloth ratio as high as 2.9 acfm per square foot; the average pressure drop across the entire baghouse under these conditions is 6.1 inches of water.
 - The baghouse supplier guarantees a pressure drop of 6.8 inches water at a gas-flow rate of 3.75 million acfm.

- A pressure drop of 1 inch of water costs \$150,000 per year in replacement power (1988 dollars).
- Improving the pressure drop by 0.7 inches of water saves an estimated \$105,000 per year in induced-draft fan power consumption (1988 dollars).
- The calculation applies a 5% escalation factor.
- During the 35-year life of the plant, the current dollar saving is about \$15.1 million, whereas the present value of this saving is \$3.5 million.
- 3. The 1988 present value calculations assume an 8.5% discount rate.

Leadership in Science and Technology

Post Office Box 10412 Palo Alto, California 94303 EPRI Hotline (415) 855-2411

The Electric Power Research Institute, EPRI, was formed to apply advanced science and technology to the benefit of member utilities and their customers.

Funded through voluntary contributions by some 600 member utilities, EPRI's work covers a wide range of technologies related to the generation, delivery, and use of electricity, with special attention paid to cost-effectiveness and environmental concerns.

At EPRI's headquarters in Palo Alto, California more than 350 scientists and engineers manage some 1600 ongoing projects throughout the world. Benefits accrue in the form of products, services, and information for direct application by the electric utility industry and its customers.

Fossil steam plant systems and performance Fossil plant air quality control

Reliability/availability, capacity and heat rate Fossil plant availability

December 1989

Appendix B

EPRI Report CS-5161, Volume 2

Sonic Cleaning Guidelines

Fabric Filters for the Electric Utility Industry

Volume 2 Sonic Cleaning Guidelines

Prepared by
C. J. BUSTARD
K. M. CUSHING
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Menlo Park, California 94026-0307

EPRI

Electric Power Research Institute 3412 Hillview Avenue Palo Alto, California 94304

WALTER PIULLE EPRI Project Manager Coal Combustion Systems Division **Ordering Information**

Requests for copies of this report should be directed to Research Reports Center (RRC). Box 50490, Palo Alto, CA 94303, (415) 965-4081. There is no charge for reports requested by EPRI member utilities and affiliates, U.S. utility associations, U.S. government agencies (federal, state, and local), media, and foreign organizations with which EPRI has an information exchange agreement. On request, RRC will send a catalog of EPRI reports.

Publication

CS-5161, volume 2

Research Project

1129-8

Topics

Baghouses Coal-fired boilers Retrofitting

ISBN 08033-5016-3

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Prepared by Southern Research Institute Birmingham, Alabama and Electric Power Technologies, Inc. Menlo Park, California



Fabric Filters for the Electric Utility Industry is a series of volumes reporting and interpreting results from over 12 years of EPRI research and development on the use of fabric filters (baghouses) for collecting particulate matter at fossil-fuel-fired electric generating plants. EPRI's ongoing baghouse research effort is designed to build a comprehensive database and to provide quantitative guidelines for all aspects of the technology.

The objective of this series is to provide plant operators, engineers, and home office managers with a hands-on reference library of practical baghouse design and operation information. Information presented is based on studies conducted at EPRI pilot plants filtering fly ash from low- and high-sulfur coals, on laboratory investigations, and on supporting field tests and utility experience at full-scale units.

Since 1975, the number of baghouses in operation, under construction, or in design in the U.S. utility industry has grown from a handful to approximately 110 associated with more than 20,000 MW of generating capacity. These units routinely have collection efficiencies higher than 99.9%, outlet emissions well below the limits imposed by New Source Performance Standards, and clear stack plumes with opacities less than 1%. Comparable performance has been experienced in Australia, where almost 50 units are in operation on about 8,000 MW of generating capacity. Baghouses also have the unique potential to interface positively with and reinforce the performance of a variety of environmental control technologies, for example, spray dryers for SO₂ control. Consequently, they could serve as a cornerstone for integrated environmental control in coal-fired power plants of the future. At EPRI, we anticipate that baghouses will play an increasing role in reducing both emissions and costs of environmental controls, thus making an important contribution to even greater acceptance of coal as a boiler fuel.

I hope you find these reports informative and useful. I would very much appreciate any thoughts and suggestions you might have on this series.

Sincerely,

Kurt E. Yeager Vice President

Coal Combustion Systems Division

Abstract

This publication is the second in a series presenting results of EPRI's research and development work applying baghouse technology to the collection of particulate matter at coal-fired electric power generating plants. The series, Fabric Filters for the Electric Utility Industry, is intended as a practical, hands-on reference for plant operators, engineers, and home office managers. Multiple volumes are planned. each to be produced sequentially over the period 1987-1989. Topics to be addressed include operating principles and terminology, baghouse design considerations, bags and fabrics, flue gas dynamics. reverse-gas cleaning, reverse-gas cleaning with sonic assistance, shake/deflate cleaning, pulse-iet cleaning, combined SO₂ collection, and operation and maintenance.

Volume 2, Sonic Cleaning Guidelines, provides practical guidelines for selecting, testing, and operating pneumatic, diaphragm-operated horns as a supplement to reverse-gas cleaning in utility baghouses.

Reductions of 20-50% in dustcake weight and tubesheet pressure drop from values experienced with normal reverse-gas cleaning have been realized with sonic enhancement. Such improvement occurs in baghouses filtering fly ash from pulverizedcoal-fired boilers burning either low- or high-sulfur coal. The degree of effectiveness depends on the coal and fly ash chemistry and the frequency and output power of the horns. Best performance is achieved using horns with output sufficient to produce average sound pressures of 80-100 Pa (about 132 to 135 dB) throughout the baghouse compartment and with output power concentrated in the frequency range below approximately 250-300 Hz. The higher sound pressure requirements occur in high-sulfur-coal applications where the fly ash is more cohesive.

This volume includes a discussion of the effectiveness of various sonic horns in pilotand full-scale testing along with costs and benefits of sonic-assisted reverse-gas cleaning. Guidelines are given for characterization and selection of horns for utility applications. Installation of horns, trial testing, operation, and maintenance are discussed. An explanation of the fundamentals of sonic technology is provided. The sonic spectra and operating characteristics of commercial horns and a list of horn manufacturers are included to help in the selection of horns.

Acknowledgments

The authors are grateful to Mr. Walter V. Piulle, of EPRI, for his guidance and assistance in producing this manual. Editorial assistance was provided by William Nesbit & Associates, Santa Rosa, CA. We would also like to express our appreciation to Dr. William Barrett for his thorough technical reviews at various stages of this endeavor and to Ms. Karen Schmitt for her diligent and thoughtful editorial review efforts. The cooperation of horn manufac-

turers was crucial to the development of the data that serve as the foundation for this work. We therefore extend our thanks to Airchime Manufacturing Co., Ltd.; Analytec; Drayton Corporation; Envirocare; Fuller Company; KVB Inc. Equipment Systems; Leslie Company; Sonic Engineering, Inc.; and Sonic Power Systems, all of whom provided horns for testing and study.

Foreword

This publication serves two purposes. First, it provides practical guidelines for selecting, testing, and operating pneumatic, diaphragm-operated horns as a supplement to reverse-gas cleaning in utility baghouses. Second, it is a reference source, containing background information and examples. As a guidelines manual, it does not discuss research methodology and data in detail. Rather, it focuses on practical issues of horn selection, testing, and operation and is intended as a working document for planning and implementing the use of horns in new and retrofit operations.

The manual draws on results from a large R&D program undertaken in 1975 to establish a comprehensive and quantitative database on baghouse technology applied to the collection of particulate matter from utility coal-fired power plants. Studies conducted in this program can be grouped into four research areas: low-sulfur-coal pilot-plant studies, high-sulfur-coal pilot-plant studies, field studies at full-scale coal-fired power plants, and supporting laboratory and special studies. Chronological results

from each of these four research areas are presented in separate report volumes. Other publications discussing additional research specific to sonic-assisted, reversegas cleaning are listed in the Bibliography of this manual. These publications may be obtained through the EPRI Research Reports Center or the EPRI Project Manager.

Early in this research effort it became apparent that some conventional terms and units of measure used in characterizing acoustic energy in other applications were inappropriate or inconvenient for characterizing horns for utility application. Consequently, more applicable units of measurement and terms that may be unfamiliar to some readers are used here. These include pascals instead of decibels to describe sound pressure, power-weighted mean frequency instead of fundamental frequency to describe where sound power is concentrated in a horn's output frequency spectrum, and geometric standard deviation to indicate the sharpness of a horn's sonic spectrum, as discussed in Section 2.

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Introduction

In many instances, sonic horns can be used in reverse-gas-cleaned baghouses to reduce high pressure drop or alleviate other problems that can result from accumulation of an excessively thick residual dustcake on the bags. Problems of this kind usually build up gradually, over a period of months. Pressure drop can become great enough to require reductions in unit load, or bags can become heavy enough to cause bag failures or even structural damage to the baghouse. If mechanical failures or poor fluid dynamic design (1) are eliminated as causes of poor performance, the use of

horns to remove excessive dustcake may be the best way to reduce the pressure drop across a baghouse. The installation of horns is simple and inexpensive compared with other remedies, and the positive results are almost immediate. Horns may also be included in the design of new baghouses to permit lower design pressure drop or higher design air-to-cloth ratio than is usual for conventional units. The procedures for outfitting a baghouse with horns are straightforward. This manual contains information and guidelines for each step.

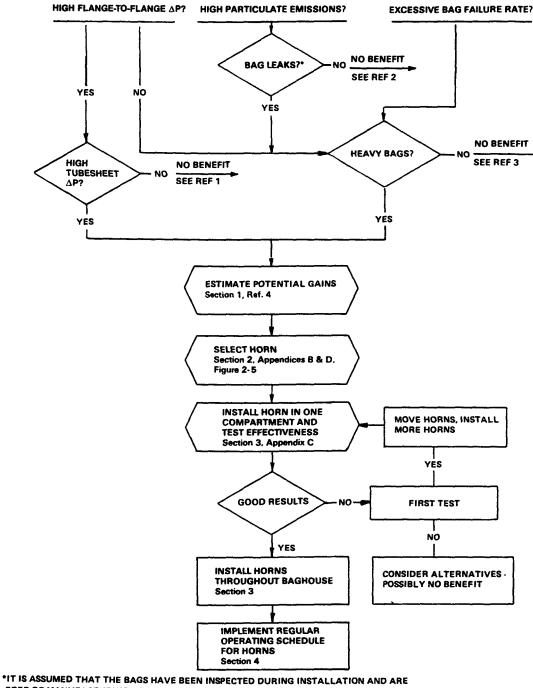
How to use this manual

Figure 1-1 is a flow chart that shows the steps for evaluating and installing sonic horns and the appropriate sections of this manual to consult at each step. It is designed as a guide to understanding when and how horns may be beneficial and to finding needed information quickly if it is determined that the use of horns is appropriate. When consulting this manual, the

reader should usually start with Figure 1-1.

The topical organization provides quick access so that the text can serve not only as a set of guidelines for the use of horns, but also as a reference manual. Information needed to evaluate the feasibility of installing horns is found in this Introduction.

CAN SONIC HORNS IMPROVE THE PERFORMANCE OF A REVERSE-GAS BAGHOUSE?



FREE OF MANUFACTURING DEFECTS.

4517-1425

Figure 1-1. Flow chart for baghouse problem evaluation. References are found on p. 5-1.

The problems with reverse-gas cleaning and the approaches to these problems that led to the use of horns are discussed in this Introduction, with a description of improvements that can be expected as well as costs and benefits of sonic-assisted reverse-gas cleaning. An illustration of a typical horn is provided, along with an explanation of the mechanics of forming sound waves in pneumatic horns.

Terminology tends to be a problem for newcomers to a specialized or technical field, and sonic horn terminology is no exception. Some of the terms may be confusing or difficult to remember, but there are a few that must be understood clearly in order to use this manual or to discuss sonic horns with vendors, consultants, or others. A brief summary of basic sonic terms, including their definitions and the basic relationships among them, is provided later in this section. Since it is likely that there will be at least an occasional need to review these important terms, their definitions are highlighted in the text.

The steps required for characterization and selection of horns for baghouse applications are provided in Section 2. The criteria that are provided to evaluate horns are based on the dependence of sonic-cleaning effectiveness on horn output power and frequency. Criteria for horn selection are provided for both high- and low-sulfur coal. Procedures are described for initial tests of a horn to obtain a spectral analysis.

Installation and compartment testing are explained in Section 3. Operation and maintenance are discussed in Section 4. The appendices contain additional information on sonic terminology, useful equations, performance characteristics of commercially available horns, examples of the spatial distribution of sound pressure in full-scale baghouses, and a list of horn manufacturers. A subject index is provided to direct the reader to the location of a specific topic.

Criteria for the selection of horns and procedures for their use presented in this manual are based on data from the application of horns to baghouses filtering flue gas from pulverized-coal-fired boilers burning bituminous or subbituminous coal. Other fuels and processes, such as lignite coal, fluidized-bed boilers, and dry scrubbing systems, may generate ashes or powders having different properties. Although the procedures described in this document are generally applicable, there is not yet enough experience in the application of horns to those systems to permit the development of specifications for those applications.

Problems in reverse-gas baghouses

Reverse-gas bag cleaning is used in more than 90% of baghouses installed on coal-fired power plants. Well-maintained units generally have very high particle collection efficiencies (more than 99.9%, with outlet emissions of approximately 0.005 lb/10⁶ Btu), clear stacks (opacities averaging less than 1%), and good bag life (averages of more than 4 years).

However, reverse-gas-cleaned baghouses are also frequently characterized by heavy residual dustcakes (from 0.5 to over 1 lb/ft², which is about 20 times the weight of dust accumulated during a single filtering cycle) and associated values of tubesheet pressure drop that tend to drift slowly upward with time from an initial value of approximately 3-5 in. H₂O to as much as 6-9 in. H₂O as the dustcake builds. Heavy residual dustcakes may cause excessive bag failures or even damage to the bag suspension system, increasing baghouse operation and maintenance costs. High pressure drop also increases operation and maintenance costs and can require boiler load reductions if the fan capacity is inadequate to overcome the pressure drop.

Approaches to solving problems in reverse-gas baghouses

There are several possible approaches for reducing tubesheet pressure drop and for reducing and stabilizing dustcake weight in reverse-gas-cleaned baghouses. These include the employment of bag fabrics that by their inherent structure and design prevent buildup of a heavy dustcake, flue gas or fly ash conditioning to develop more porous or more easily removed dustcakes (for example, introduction of electric charge or gaseous or solid chemicals), and the application of more energy in the bagcleaning process. Development of improved bag fabrics and flue gas and fly ash conditioning techniques, however, are still in the early research stage.

Application of more energy to improve the reverse-gas cleaning process has been investigated in a variety of ways. Increasing reverse-gas flow rate is one. Testing. however, indicates that pressure drop is not reduced substantially, even at very high rates of reverse-gas flow. Hand clapping or mechanical shaking of bags is another option, one which many utilities have employed intermittently. Although this is an effective procedure, it is very timeconsuming and labor intensive, and the reduction in pressure drop achieved by this method lasts only a few days or weeks. The third, and favored, option is sonic assistance, or the use of horns.

How sonic horns can help

In the application of horns, high-power, low-frequency sound is used simultaneously with reverse-gas flow. The resulting agitation of the fabric and dustcake structure effectively removes a large portion of the dustcake collected during filtration and prevents the buildup of excessively thick residual dustcakes.

Sonically enhanced bag cleaning is accomplished by a coupling between the bag and dustcake and the sound waves generated by the horn. A mechanical effect. this coupling is dependent on the response of the bag to pressure variations in the air. As a sound wave reaches the surface of the bag, the oscillations in air pressure exert forces that cause the bag to vibrate at the frequency of the sound wave. The magnitude of these induced vibrations at a specific location on the bag depends on the sound pressure in that region and the mechanical characteristics of the bag and dustcake. At high enough sound pressure levels, the dustcake tends to crumble and break up as a result of the vibrations. This action, combined with reverse-gas flow, is very effective in preventing the buildup of excessively thick, heavy dustcakes.

Operating improvements achievable with horns

Sonic enhancement of bag cleaning with horns is a very effective option for improving the reverse-gas cleaning process in both new and retrofit applications in utility baghouses. Properly applied, sonicenhanced, reverse-gas bag cleaning is more effective than either reverse-gas or sonic cleaning alone. In applications in a number of full-scale baghouses filtering fly ash from pulverized-coal-fired boilers burning either low- or high-sulfur coal, dustcake weight and tubesheet pressure drop reductions of 20-50% have been realized. Horns have been operated in some baghouses for more than four years, and no detrimental effects have been observed. Rather, it is more likely that sonic cleaning will extend bag life by reducing the strain on both the fabric and the tensioning system that results from excessive dustcake weight.

Reductions in dustcake weight

Residual dustcakes, which accumulate and remain more or less permanently attached to the bag, are the most important factor influencing baghouse collection efficiency and pressure drop. They must be thick enough to achieve efficient particle filtration, but thin and porous enough to maintain low pressure drop and light enough to avoid straining the bags or their supports. For most baghouse applications, ideal residual dustcake weight would be on the order of 0.2-0.4 lb/ft², or 20 lb for a conventional bag 30 ft long by 12 in. in diameter. Excessive residual dustcake weights tend to increase pressure drop and to strain bags and tensioning systems.

Although this ideal value of dustcake weight is seldom attained, in baghouses filtering ash from western, low-sulfur coal, the employment of sonic-assisted reverse-gas cleaning can reduce residual dustcake weights from about 0.6 lb/ft² to about 0.3 lb/ft². For baghouses filtering ash from eastern, high-sulfur coal, sonic assist can reduce residual dustcake from as high as 1.2 lb/ft² to about 0.6-0.7 lb/ft².

Reductions in pressure drop

Early testing to evaluate the effects of sonicassisted, reverse-gas cleaning on pressure drop was conducted at EPRI's low-sulfurcoal Fabric Filter Pilot Plant (FFPP) at the Public Service Company of Colorado's Arapahoe station in Denver and at three full-scale plants. Figure 1-2 shows that tubesheet pressure drop was reduced in every instance.

The proportional reduction compared with normal reverse-gas operation varied from plant to plant because of differences in coal chemistry and operating conditions. All four plants used individual horns having nearly

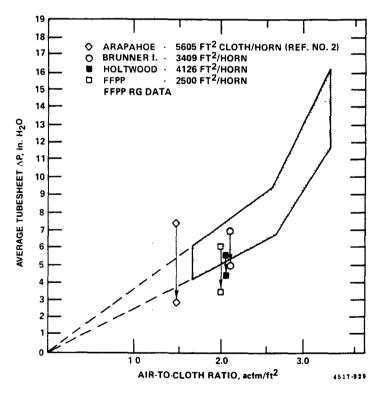


Figure 1-2. Reductions in pressure drop as a result of horn use. The data from full-scale power plants are superimposed, for comparison, on the shaded area that represents operation of the Fabric Filter Pilot Plant as a normal reverse-gas-cleaned (RG) unit.

identical total sonic output characteristics, but the average area of filter cloth cleaned by each horn varied widely, as did the compartment geometry and the sulfur content of the coal.

Fuel sulfur content appears to be a primary factor influencing a dustcake's tendency to cling to a bag and, hence, horn effectiveness. The baghouses filtering fly ash from western, low-sulfur coals (Arapahoe Unit 3 and the FFPP) achieved pressure drop reductions of 50-60%, while the baghouses filtering fly ash from eastern, high-sulfur coals (Brunner Island and Holtwood) achieved pressure drop reductions of 20-30%.

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Costs and benefits of sonic-assisted reverse-gas cleaning

The capital cost of a typical pneumatic, diaphragm-operated horn is in the range of approximately \$800-\$2000. Additional costs may be incurred for a large air compressor if one of adequate capacity is not already available at the plant. In typical applications, the investment required to retrofit horns throughout a baghouse for a 500-MW unit could be as high as \$700,000 for a plant burning high-sulfur coal or \$300,000 for a low-sulfur unit. This estimate includes the assumption that installation costs are approximately equal to the cost of the horns.

Annual savings from the reduction in pressure drop resulting from the use of these horns would amount to \$300,000 for the high-sulfur plant and \$750,000 for the low-sulfur unit. Even greater savings may be realized by avoiding costly boiler derating due to insufficient fan draft to overcome the pressure drop. An important additional benefit is the reduction in maintenance costs derived from the more complete removal of dustcake.

The operating cost of horns is a very small fraction of the cost of operating a baghouse. A calculation based on the pressure and

flow rate of air supplied to each horn in a baghouse indicates that less than 0.1 in. H_2O reduction in pressure drop across the tubesheet is required to pay for the cost of horn operation.

In new baghouses, the lower range of pressure drop achievable with horns offers the potential for a higher design air-to-cloth ratio (A/C) and, thus, lower capital costs. Considering the costs of capital equipment, power consumption (pressure drop), and operation and maintenance, sonic assistance can reduce the levelized cost of a new baghouse by as much as 10%. For example, using as a baseline case an existing reverse-gas-cleaned baghouse at an A/C of 2.0 acfm/ft², the approximate cost savings of the hypothetical sonic-assisted, reverse-gas-cleaned baghouse over the existing one would be as follows (4):

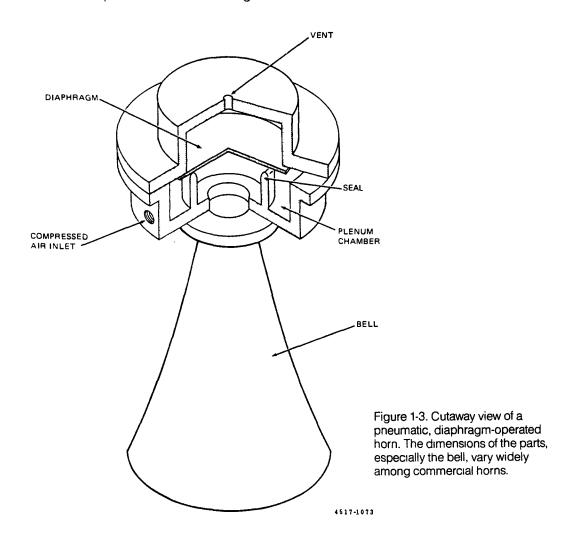
- capital costs reduced by about 18%,
- power costs reduced by about 13%, and
- operation and maintenance costs reduced by about 5%.

Operating principle of pneumatic horns

Pneumatic, diaphragm-operated horns are used as sound generators for baghouses because they are durable, uncomplicated, and capable of producing sounds of appropriate frequency and power. Whistles and sonic impulse generators are potentially suitable alternatives to horns, but as yet none of these types of devices has been thoroughly characterized and assessed in utility baghouse application. In this document the term "horn" refers exclusively to pneumatic, diaphragmoperated horns.

Figure 1-3 illustrates the common features of a pneumatic, diaphragm-operated horn. In operation, compressed air is introduced into the inlet plenum chamber through the

air inlet. As the pressure in the plenum builds, it reaches a level at which it pushes the metal diaphragm away from the seal, creating a gap and allowing the air to rush out, producing an intense sound. As the pressure in the plenum falls, the diaphragm snaps back into position on the seal, and the sonic impulse ends. The cycle repeats as the pressure again builds in the plenum chamber producing intense sound in the form of a train of high-pressure pulses of air, with one pulse emitted each time the diaphragm is forced away from the seal. Factors affecting the character of the outlet sound include supply air pressure, the sizes of the inlet plenum chamber and the compressed-air inlet opening, the mass



and stiffness of the diaphragm, and the length and shape of the bell.

Although horns are usually audible outside a baghouse compartment, the sound level is no higher than that of noises normally associated with a utility boiler operation. Since the horns are operated only inter-

mittently and for short periods of time, the sound is not objectionable. Outside the compartment, horns pose no physiological threat to hearing. Ear protection must be worn when testing horns outdoors, however, and no one should be allowed inside a compartment while horns are sounded.

Basic sonic terminology

Frequency, sound pressure, amplitude, wavelength, power, and intensity

A sound wave is a series of periodic variations in air pressure characterized by a frequency, measured in cycles per second. or hertz (Hz), and a sound pressure, measured in pascals (Pa). Frequency is the number of times per second a peak value of pressure occurs at a fixed point. Amplitude in terms of sound pressure expresses the magnitude of the variations from atmospheric pressure. Depending on the context, the amplitude of a sound may refer to either the maximum pressure associated with the wave or the maximum displacement distance of the air molecules from their equilibrium positions during the passage of a sound wave. Because of the possible ambiguity, the term "amplitude" will be avoided in favor of "sound pressure."

From these parameters, the related quantities of wavelength, power, and intensity may be derived. The wavelength of a sound is the distance between successive points of maximum instantaneous pressure. It is determined by dividing the speed of sound by the frequency. *Power* is proportional to the square of the pressure and is expressed in watts. *Intensity* is the power density in a localized region; its units are watts per square meter (W/m²).

Sound power level and sound pressure level

Sound power level and sound pressure level are specialized terms referring to a measurement made relative to some standard reference level and expressed on a logarithmic scale. The units for either term are called decibels (dB). The word level is the key word that distinguishes between the more practical linear measures of pressure and power and the logarithmic ratios of pressure level and power level.

The standard reference level for sound power level is 10⁻¹² W (0 dB) and that for sound pressure level is 2 x 10⁻⁵ Pa (0 dB). Since power is proportional to the square of pressure, the decibel levels of power and pressure are approximately the same under ordinary atmospheric conditions and are used interchangeably in this text to characterize horns. Decibel units may be used to characterize single-frequency sounds or complex waveforms.

Comparable values of sound pressure level in decibels, sound pressure in pascals, and intensity in watts per square meter are illustrated by parallel scales in Figure 1-4, which may be used for making approximate conversions between the three sets of units. More information on decibels, the conversion from decibels to pascals, and related sonic terminology can be found in Appendix A.

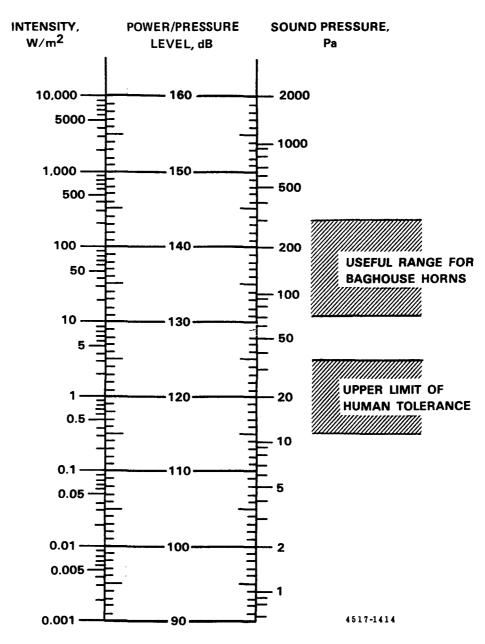


Figure 1-4. Parallel scales illustrating the relationships between sonic intensity (power density), decibel level, and sound pressure.

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Total output power, integrated sound pressure, and fundamental frequency

By convention, a horn is often designated in terms of its total output power and its fundamental frequency. Total output power is proportional to the square of the integrated sound pressure and is derived from the integrated sound pressure, which is the quantity measured by most simple sound meters. Therefore, the term "total output power" is used interchangeably with "integrated sound pressure output" in this manual. Integrated sound pressure is the root mean square sum of pressure taken over all frequencies. It is primarily determined by the geometry of the horn and, secondarily, by the pressure of the air supplied to the horn. (Literature on sonic horns uses various terms for these values, such as "integrated power output" and "total sound pressure output.")

Fundamental frequency, the lowest frequency at which the horn will resonate, is often used to describe horns because of its direct mathematical relationship with the horn's geometry: the wavelength of the fundamental is approximately twice the length of the bell.

Fundamental frequency, however, is not the best, or even an adequate, characteristic to indicate a horn's performance for bag cleaning. To illustrate, consider the following discussion. It is very unusual to encounter a sound consisting of a single frequency. Most sounds comprise a combination of many frequencies, some harmonically related and some not. The sonic output of a horn invariably contains a mixture of components having various frequencies. Figure 1-5 shows a comparison between a sine wave (the dashed curve) representing

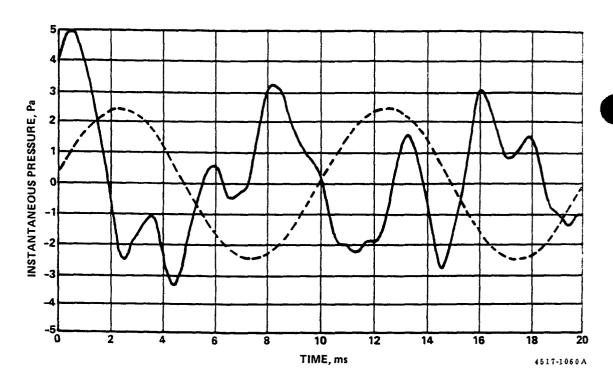


Figure 1-5. Waveform of a sound produced by a horn (solid line) compared with the waveform of a pure tone (dashed line). The fundamental frequency of the horn is the same as the frequency of the pure tone (100 Hz).

a single, pure tone, and another, more complex waveform. The latter is similar to what would be observed if a microphone connected to an oscilloscope were placed near the type of horn used in baghouse applications. The sine wave source and the horn both have fundamental frequencies of approximately 100 Hz, but the horn's waveform is irregular and sharply peaked, because horns typically produce sounds whose power is distributed unevenly across a sonic spectrum.

It is very difficult to make any kind of interpretation of this irregular waveform. But the same information, plotted in the form of a sonic frequency spectrum as in Figure 1-6 can be quite useful. The graph shows the measured sound pressure in each of eleven logarithmic intervals, all of which are one-third-octave wide. (Tones differing in frequency by a factor of two are said to be an

octave apart, and three successive bands span an octave.) In this example, the sound is not concentrated precisely at the fundamental frequency (which is 125 Hz) but is fairly strongly peaked at or near 160 Hz with progressively smaller components of higher frequency. Figure 1-6 is fairly typical of one-third-octave analyses achievable with readily available instrumentation.

From this discussion, it is clear that the fundamental frequency is an incomplete and possibly misleading indicator of the potential effectiveness of a horn. A procedure for averaging the frequencies determined with a one-third-octave analysis that has proven more useful for evaluating horns is discussed in Section 2.

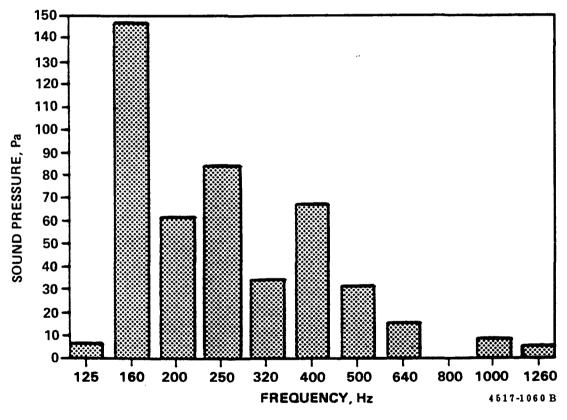


Figure 1-6. Sonic spectrum of a complex waveform, represented as a one-third-octave analysis.

Essential Concepts and Units

- Frequency, f (hertz, Hz)—number of vibrations (cycles) per second.
 Fundamental frequency—lowest resonant frequency of a horn.
- Sound pressure, p (pascal, Pa)—rms variation from ambient pressure, measured at a point.
- Integrated (or total) sound pressure—combined sound pressure of all components, measured at a specified distance from the source and integrated over all frequencies.
- Sound pressure level and sound power level, L (decibel, dB)—logarithmic
 expression for sound pressure or power referred to a standard value (10⁻¹² W for
 power, 2 x 10⁻³ Pa for pressure). May be applied to a single frequency or a complex
 combination.

(See also pages AT A9)

Section 2

Characterization and Selection of Horns

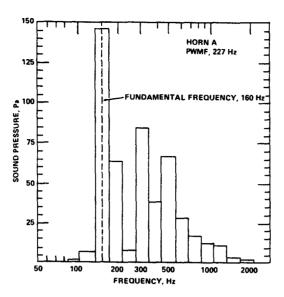
Frequency

Selection from among the variety of horns commercially available for baghouse application is not straightforward. Recent laboratory and pilot-plant studies have demonstrated the importance of using horns with sufficient output power concentrated in the frequency range below approximately 250-300 Hz, the most effective range for cleaning bags (5).

Confusion may arise because the parameters generally used to describe horns, fundamental frequency and total output power, do not adequately indicate a horn's effectiveness for bag cleaning. Fundamental frequency, which is the lowest resonant frequency of a horn, is not a reliable indicator of a horn's effectiveness in baghouse applications. In looking at the sonic spectra of commercial horns, it is clear that in many instances only a small portion of the total output power is found at frequencies near the fundamental, while comparatively very strong peaks in the spectrum occur at less effective higher frequencies. Total output power of a horn also does not indicate

where output power is concentrated in a horn's frequency range. Consequently, two horns rated at the same fundamental frequency and the same total output power (which is derived from integrated sound pressure output) may produce quite different results in a baghouse.

This problem is illustrated by two hypothetical horns characterized by the sonic spectra shown in Figure 2-1. They have the same fundamental frequency (160 Hz) and integrated sound pressure output (200 Pa, or 140 dB); but the output from Horn A is much more strongly concentrated in the lower, more effective bag cleaning frequency range than is the output from Horn B.



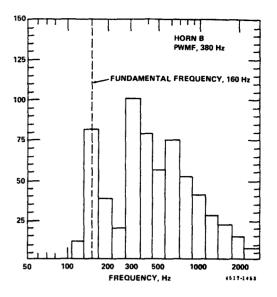


Figure 2-1. Sonic spectra for two hypothetical horns. Both have a fundamental frequency of 160 Hz and a sound pressure output of 200 Pa, integrated over all frequencies.

Power-weighted mean frequency (PWMF) and geometric standard deviation

Since fundamental frequency is unsuitable for evaluating horn effectiveness, two other quantities, based on conventional statistical methods, have been defined to aid utilities in choosing appropriate horns:

- Power-weighted mean frequency—the logarithmic average of the frequency spectrum, weighted by the power at each frequency. Since this is the mean frequency at which the power is concentrated, this value must tall below 250-300 Hz for a horn to be effective. (This criterion is established later.) Throughout this manual, the power weighted mean frequency will be abbreviated PWMF, and it will be represented in mathematical expressions by the symbol. In Figure 21, the power weighted mean frequency of Florr A is 227 Hz, which is in the desirable range, while the power-weighted mean frequency of Horn B is 380 Hz, which is higher than outmum for pag cleaning and would thus require more total output power to be as effective.
- **Geometric standard deviation**—a measure of the breadth of the distribution of sonic power across the frequency spectrum, symbolized by σ_s . This quantity defines the degree to which a hom's total butput power is concentrated near its power-weighted mean frequency, or the "sharpness" of its spectrum. For a pure tone, $\sigma_s = 1.0$. A desirable value of geometric standard deviation would be approximately in the range from 1.0 to 2.0.

Figure 2-2 illustrates that horns with PWMFs below 250-300 Hz are more effective in reducing tubesheet pressure drop than are horns with the same total output power but

with PWMFs above 300 Hz. (Pressure drop values in Figure 2-2 are shown as fractions of ΔP achieved with reverse-gas cleaning alone.)

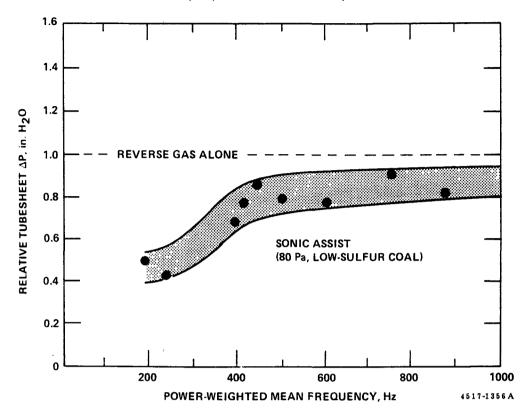


Figure 2-2. Effect of varying the power-weighted mean frequency of a horn on the reduction in pressure drop across the tubesheet of a fabric filter. All tests were made at an average integrated sound pressure output of 80 Pa.

Power requirements for high- and low-sulfur coal

Much more power is required to remove equivalent amounts of fly ash derived from eastern, high-sulfur coal than from western, low-sulfur coal. Integrated sound pressure output (compartment average) of approximately 110 Pa (about 135 dB) is required for high-sulfur coal, while an output of 80 Pa (about 132 dB) is required for low-sulfur

coal. This difference is attributed to the fact that fly ash from high-sulfur coal is more "sticky" or cohesive than that from low-sulfur coal, as is indicated by the comparatively large dustcake weights that occur in baghouses that filter flue gas from plants burning high-sulfur coal.

Figure 2-3 shows the results of experiments to determine the different effects of integrated sound pressure in reducing residual dustcake from high- and low-sulfur coal. The PWMF of these horns (211 Hz) was in

the proper range for effective cleaning; acoustic power and dustcake weights were measured at localized points within the baghouse compartments.

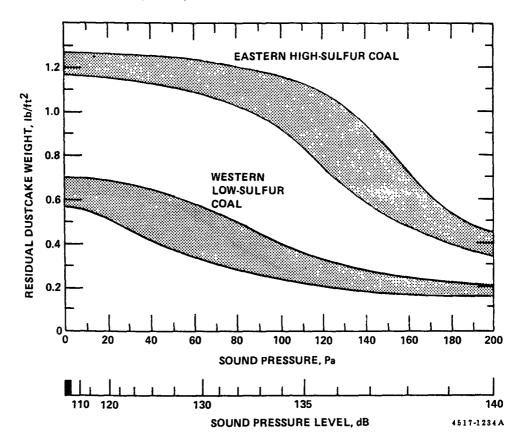


Figure 2-3. Effect of the local integrated sound pressure in a baghouse compartment in reducing the weight of the residual dustcake from high- and low-sulfur coal. The power-weighted mean frequency was 211 Hz for all tests represented on this graph.

Analysis of the sound pressure spectrum of a horn

Since an accurate assessment of how total output power is distributed across the frequency spectrum is essential to evaluating horns for bag-cleaning applications, prospective users should carefully examine sound pressure spectra as part of the selection process.

Along with PWMF and geometric standard deviation, the integrated sound pressure output at a specified distance (normally 1 m) from the horn's bell (a rating usually available from the manufacturer) and a graph of the horn's output spectrum are key measures for characterizing horns for bag cleaning.

Procedures for performing a spectral analysis

PWMF and geometric standard deviation can be calculated for a commercial horn based on spectral analysis, which provides a set of sound pressure measurements as a function of frequency. Such an analysis can be performed with a conventional sound pressure level meter calibrated in decibels (dB) and equipped with a set of electronic filters such as those used for one-third-octave analysis. (An octave is the interval between two frequencies that differ by a factor of two.)

Unless an anechoic chamber (one which is free from echoes and reverberations) is available, horns should be tested outdoors in a free-air environment and oriented so that their bells point skyward, away from any source of reflection. Testing personnel must wear ear protection. A calibrated microphone, which can be obtained as an accessory with the sound measurement equipment, should be hung from a boom and positioned at the closest distance (not less than 1 m) above the horn's bell mouth that allows measurements at all conditions without driving the meter off scale. The microphone cable can then be connected to the sound pressure level meter so that readings can be taken.

In comparing the sound pressure from two or more different sources where different measuring distances are used, it can be assumed that sound power is inversely proportional to the square of the distance from the bell mouth. Although this assumption is an approximation based on emanation from a point source, measurements on sonic horns have shown that it is accurate within about 20% (in pressure units) for horns. The convention used throughout this document is to normalize all output data to a range of 1 m from the center of the bell opening for the purpose of comparing horns.

Calculation of sound pressure from sound pressure level

It is easier to compare horns with regard to their effectiveness in applications such as bag cleaning if their output is characterized with the linear scale associated with sound pressure measured in pascals rather than with the logarithmic scale associated with sound pressure level measured in decibels. Most commercial instruments, however, indicate sound pressure level in decibels. The conversion to pascals can be estimated from the scale in Figure 1-4. To convert the meter readings mathematically from decibels to the more useful linear scale of sound pressure in pascals (Pa), the following equation may be used:

$$p = p_0 \log^{-1} (L_p/20) \tag{2-1}$$

where

p =sound pressure in pascals

 $p_0 = 2 \times 10^{-5}$ Pa, the reference sound pressure level for 0 dB

 L_p = measured sound pressure level

Sound pressure can be calculated from sound pressure level for single-frequency sounds or for total, integrated values for complex sounds. More information on the relationships among decibels, pascals, and other sonic units can be found in Appendix A.

Calculation of integrated sound pressure

Calculating the combined sound pressure of two or more components over a frequency range of particular interest to obtain the integrated sound pressure is done by adding the squares of the sound pressure components (in pascals) and taking the square root of the sum. Integrated sound pressure below 300 Hz can also be evaluated in this way. Simple addition of sound pressure components in pascals or sound pressure levels in decibels will not work. (Sufficient data are contained in Figure 2-1 and Appendix B for interested readers to confirm their calculation procedures.)

Determination of power-weighted mean frequency and geometric standard deviation

A typical one-third-octave analysis provides a set of measurements taken at discrete logarithmic intervals across the acoustic spectrum. A variety of averaging methods could be employed to yield a single number indicative of a horn's potential effectiveness in bag cleaning. It is not feasible, however, to derive a meaningful number from the simple average value of sound pressure readings. That approach would require including the relationships among the phases of the components and developing a vector average. In general, the averaging scheme must weight the measured values according to the square of the sound pressures.

Sound pressure measurements can be averaged using classical statistical procedures, however. Given a set of n values for sonic pressure, each corresponding to a one-third-octave band of frequencies centered on f_i , the power-weighted mean frequency and the geometric standard deviation can be calculated.

Power-Weighted Mean Frequency
 This logarithmic (or geometric) average value of the frequency, weighted on a power basis, is calculated with the following formula:

$$f_{\mu} = \exp \frac{-\frac{\hat{\Sigma} p_i^2 \ln(f_i)}{\hat{\Sigma} p_i^2}}{\hat{\Sigma} p_i^2}$$
 (2-2)

where

 f_{μ} = power-weighted mean frequency (logarithmic average)

n = number of values for sound pressure and frequency

 p_i = values for sound pressure

 f_i = central frequency

The value f_{μ} is computed from the squares of the sound pressures. Since sound power is proportional to the square of the sound pressure, f_{μ} is the powerweighted mean frequency.

Geometric standard deviation
 The geometric standard deviation is defined as the root-mean-square average of the difference between a measured frequency value and the PWMF:

$$\sigma_g = \exp \left[\frac{\sum_{i=1}^{n} \rho_i^2 \ln^2(f/f_\mu)}{\sum_{i=1}^{n} \rho_i^2} \right]^{1/2}$$
 (2-3)

where

 σ_a = geometric standard deviation

The breadth or "sharpness" of the distribution of sound power across the acoustic spectrum is characterized by the geometric standard deviation.

For example, as a result of carrying out the calculations defined by these equations, it can be determined that the PWMF of the horn described by the spectrum in Figure 1-6 is 209 Hz, and the geometric standard deviation is 1.45.

Graph of a sound pressure spectrum

Readings taken from the sound pressure level meter and converted to pascal can be plotted in the form of a sound pressure spectrum (graph of sound pressure vs. frequency) in one-third-octave bands as shown in Figure 1-6 for a sample horn. Three successive bands in the figure span an octave. (More sophisticated spectrum analyzers are available which may yield data in other formats or in more detail. Such instruments are certainly adequate for obtaining spectrum, but data reduction and interpretation from a series of commercial instruments is beyond the scope of this document.)

Examination and comparison of sound pressure spectra

PWMF, σ_g , and the proportion of power in the low-frequency range are the critical parameters for horn performance in baghouses. If the criteria for low PWMF, small σ_g , and high power (integrated sound pressure output) are met, a horn will perform efficiently and satisfactorily, but unfortunately, it is not possible to develop a simple formula that can be used to reject only the horns that will not work effectively.

For example, a horn may have sufficient power in the frequencies below 250-300 Hz to effectively clean bags, but its PWMF could be higher than 300 Hz because of the additional power located in higher (but less useful) frequencies. A complete evaluation must therefore include examination and comparison of the sound pressure spectra for each candidate horn.

To illustrate how to evaluate horns based on these data, consider Figure 2-4 where several examples of hypothetical sound pressure spectra that might be obtained are shown, with the PWMF, geometric standard deviation (σ_a) and sound pressure at a similar measurement point integrated over all frequencies from 80 to 2,000 Hz for each. In this figure, horn 1, with a sharply peaked spectrum and a low PWMF, would be effective in removing dustcake from a filter. The spectrum for horn 2 is even more sharply peaked than that of horn 1, and this horn has about 15% greater integrated sound pressure output. However, the entire spectrum for horn 2 lies above 300 Hz, so it would require much more power to be useful for dustcake removal.

Horn 3 has a very broad spectrum, as shown in Figure 2-4. This horn would probably be at least as effective in a baghouse as horn 1 would, because its spectrum almost completely overlaps the spectrum for horn 1. Horn 3 is less efficient because a large amount of its integrated sound pressure output (corresponding to more than 80% of its power) is emitted in the frequency range above 300 Hz. This inefficiency may not be an important consideration, however, because the cost of operating horns is very low. The comparison of spectra for horns 1 and 3 illustrates that PWMF and integrated sound pressure can not be used to distinguish unambiguously between some horns without some judgment in interpreting spectra.

Horn 4, which also has a broad spectrum, would be a poor performer in a baghouse, although it has a high integrated sound pressure output compared with that of horns 1 and 2. In the low-frequency range, horn 4 is much weaker than horns 1 and 3, and at high frequencies, where the sound is ineffective for dustcake removal, the sound pressure generated by horn 4 is greatest.

Tests of integrated sound pressure output and air consumption

In addition to examining their output spectra, integrated sound pressure output and air consumption of horns should be tested at a range of supply-air pressures, for example, of 50, 60, 70, 80, 90, and 100 psi, unless the manufacturer specifies a lower value of operating pressure. Readings taken for a horn at different levels of supplyair pressure will establish the relationship between air supply and the resultant integrated sound pressure and sonic spectrum. These data will also show whether the air compressor has sufficient capacity to supply a given horn and will enable the operator to set the compressor at an efficient pressure setting.

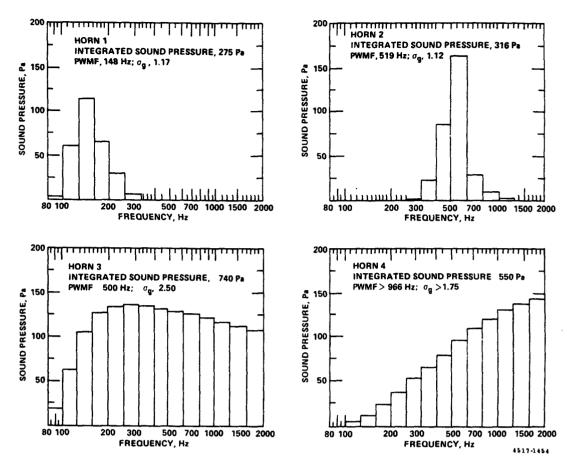


Figure 2-4. Four examples of hypothetical sound pressure spectra, showing extreme values of characteristic parameters.

Comparison and selection of horns

Criteria for effective horns

Based on the data and discussions presented above, it is possible to establish criteria for guiding the selection of horns suitable for cleaning bags:

- "ideal" horn
- Power-weighted mean frequency below 250-300 Hz.
- Geometric standard deviation less than 2.0.
- Integrated sound pressure of approximately 200 Pa (140 dB) at a point 1 m from the bell mouth.
- "Effective" horn Fundamental frequency below 300 Hz
- Integrated sound pressure in range below about 300 Hz of at least 100 Pa (-134 dB) for low-sulfur applications or 160 Pa (138 dB) for high-sulfur applications at a point 1 m from the bell mouth.

Additional considerations in selecting horns are the initial cost, installation cost, and operating costs (such as compressed-air consumption and maintenance). Measured values of PWMF, geometric standard deviation, integrated sound pressure, and air consumption for most commercial horns now available can be found in Table B-1 in Appendix B.

Appendix B also includes one-third-octave spectra for horns that are currently available. These data, along with cost quotations, can be used to select horns for a particular baghouse application.

Procedures for evaluating horns

Figure 2-5 is a logic diagram summarizing all the procedures for using these criteria to evaluate a horn's potential effectiveness for bag cleaning. This figure can be used in conjunction with Figure 1-1 to evaluate and select horns.

The requirement for a fundamental frequency less than 300 Hz is a necessary but not sufficient condition for selection. If the fundamental frequency is above 300 Hz, then no significant sound pressure will be found in the useful range. Since many manufacturers advertise the fundamental frequencies of their horns, this step is a quick and easy screening procedure.

In the outdoor screening tests, minimal values of integrated sound pressure are specified for measurements made at a distance of 1 m from the horn. Again, the condition is necessary but not sufficient for selection. It cannot be determined accurately how the horn will behave in a baghouse compartment by free-air testing, but it is not possible to meet the criterion for a specified average sound pressure throughout a compartment if the measurement at close range is below the required value.

If the PWMF is less than 300 Hz, a detailed analysis of the sonic spectrum of a horn may be bypassed, and tests in a selected compartment may be set up. Otherwise, it is necessary to plot a graph of the spectrum as measured in the outdoor testing and evaluate the result by comparing it with the examples shown in Figure 2-4 as explained by the accompanying text in Section 2. This procedure may appear to be somewhat less objective than the PWMF criterion, but if it is done carefully, while keeping in mind the general requirement for high levels of sound pressure at low frequencies, there should be no real problem in making a suitable judgment. As an example, a practical reason for selecting a horn with less than ideal output characteristics would be relatively low initial or operating costs.

The screening measures described in the foregoing paragraphs are useful in minimizing the number of competing horns that must be tested in a compartment. Since each of these tests involves a matrix of many measurements, they are timeconsuming, and hence, can be costly.

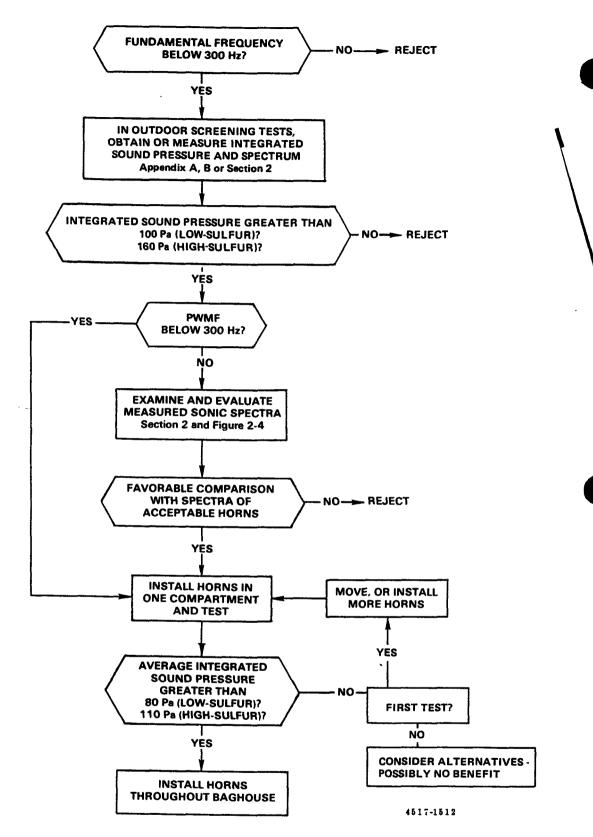


Figure 2-5. Procedures for horn evaluation and selection.

Horn Installation And Evaluation

Each baghouse system will interact in its own way with a given set of horns. The optimum number and placement of horns will vary depending on such characteristics as boiler type, fly ash chemistry, and compartment geometry. Consequently, trial-installation testing should be conducted off-line and on-line in one baghouse compartment.

Choosing the number of horns per compartment

Some full-scale baghouses have as few as four and others as many as twelve horns per compartment. As a basis for choosing a number of horns for trial testing, a ratio of one horn for each 3000-8000 ft² of fabric is recommended. This is a broad range, but this ratio varies greatly because of the wide range of ashes and baghouse designs. As a general rule, the higher the sulfur content (cohesivity) of the fly ash being filtered, the more horns will be required.

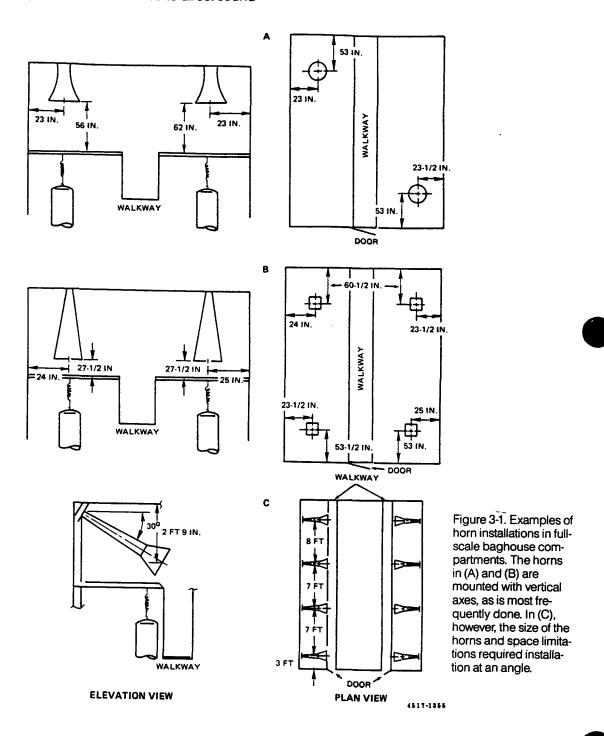
If sound pressure is reduced below required values as a result of absorption by bags, dustcake, or internal insulation, additional horns may be required. Absorption by insulation can be reduced by covering it with lagging. If sound pressure is unevenly distributed because of reflection by walls, tubesheets, bag caps, or other internal structures, the horns may need to be shifted to different positions in the compartment.

Existing data indicate that average integrated sound pressure in a compartment should exceed 110 Pa for the more cohesive ash that results from high-sulfur coal and 80 Pa for the less cohesive ash of low-sulfur coal. (Refer to Figures 1-2 and 2-3.) Since sound pressures from different sources do not add linearly, it may be more practical to use a few high-output horns than a large number of horns with low output power.

Positioning the horns

Conventional baghouse compartment designs usually dictate that horns be mounted in the space at the top of the compartment and oriented to direct sound

downward. The open spaces between bags form unobstructed channels for the propagation of sound vertically. Typical installations are illustrated in Figure 3-1.



Because of the horn's locations, sound pressure usually is greater near the top of a compartment than near the bottom, and dustcake dislodgement due to the sonic agitation is more effective near the top. As the dustcake falls, however, it strikes the surfaces in the lower regions of the bag, and causes additional removal of dust to occur. Thus, although the sound pressure may be somewhat lower near the bottom of the bags, no apparent disadvantage results from locating the horns near the compartment ceiling.

The most critical factor in horn placement is to avoid pointing the bell opening toward a nearby, rigid, sound-reflecting surface. The horns should be spread out in the bag compartment, although placement need not be precise. Sound can be distributed uniformly even if one of the horns is mounted a foot or so from what might appear to be the best position.

Providing sufficient air supply

Unrestricted distribution of the air supply to the horns requires a large feeder pipe to each compartment, a solenoid valve at each compartment, and delivery lines from the valves to each horn. If several horns are to be operated simultaneously, conservative design of the compressor, piping, and air receiver and drying systems is necessary to ensure adequate air pressure and flow rates to drive the horns. Since large pressure losses can occur in the supply lines, piping in the compressed-air distribution system must be large enough in diameter to ensure that proper flow rate and pressure, 40-150 scfm at up to 100 psig for most commercial horns (see Table B-1), can be provided.

Since only one baghouse compartment is cleaned at a time, the compressed-air system can recover its pressure between two successive operations; thus, the capacity of the compressor and accumulator tank can be selected to provide only the amount of air flow required for the horns in a single compartment. This air supply distribution system should be designed to operate all the horns in one compartment while maintaining the horn inlet air pressure required by the manufacturer for up to 30 s.

Testing

}

Proper trial testing includes four steps: 1) recording pressure drop and bag weights before horn operation, 2) activating the horns while taking a comprehensive series of sound pressure readings (with the compartment off-line), 3) monitoring tubesheet pressure drop throughout an on-line test, and 4) weighing bags a second time to compare with the initial weights. Steps 1-4 all are required for retrofit applications while only step 2 is necessary for new baghouses.

Recording pressure drop and bag weights

First, tubesheet pressure drop readings should be taken during regular reverse-gas operation before the horns are turned on. Bag weights should also be recorded.

Taking sound pressure readings while activating horns

Second, the test compartment should be taken off-line, and sound pressure measurements should be made throughout the compartment, with horns operating, to verify acceptably uniform distribution of the minimum required sound pressure and to document the frequency spectrum of the horn's output. This is the phase of installation and testing during which horns may be moved or more horns may be added to improve sound pressure distribution. If the placement of horns is changed, testing should be repeated.

To confirm that minimum adequate sound pressure is achieved throughout the compartment, tests should be conducted with a

meter designed to measure integrated sound pressure levels up to at least 140 dB (200 Pa) and capable of at least one-third-octave resolution. All sonic measurements must be made with a full complement of bags in the compartment.

Mapping distribution of sound pressure throughout a baghouse. Mapping the distribution of sound pressure throughout the volume of a baghouse requires a large number of individual measurements. An efficient way to acquire the necessary data is to make vertical traverses at selected measurement positions in the horizontal plane. A simple rope suspension for a microphone and cable is suitable and easy to rig. The microphone cable should be long enough to reach a position outside the compartment. No one should be allowed inside the compartment while the horns are being sounded.

Each traverse can be made by pulling the calibrated microphone upward, in steps of about 1 ft, from the tubesheet to the height of the bag caps. A reading of integrated sound pressure is made at each stop. Each

vertical traverse may require thirty or more measurements. Readings should be taken only when the supply air pressure is steady at its nominal maximum. If the compressed-air pressure drops off because of the unusually high flow demand required for this kind of testing, measurements should be taken less frequently so that the air supply system can recover and maintain pressure.

Measurements along a vertical traverse are made fairly close together because standing wave patterns caused by reflections from rigid surfaces can produce large variations in sound pressure over the length of the bags. Since the sonic frequencies of greatest interest are less than about 300 Hz. it is not necessary to investigate effects of standing waves shorter than about 4 ft in wavelength. Four or more measurements per wavelength are enough to detect standing waves, so intervals of about 1 ft are acceptable for the vertical traverse. Figure 3-2 shows typical integrated sound pressure values (Pa) and sound pressure levels (dB) in a full-scale utility baghouse compart-

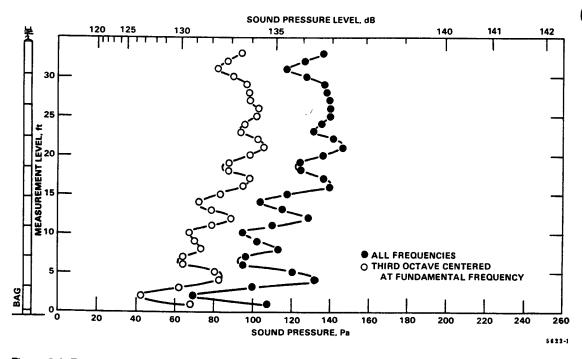


Figure 3-2. Typical variations in integrated sound pressure as a function of height above the tubesheet. The data were taken in a full-scale utility baghouse with four horns.

ment containing four horns. Variations in sound pressure resulting from standing waves are clearly evident, especially in the lower region where the incident wave and the wave reflected from the tubesheet are of nearly the same magnitude.

Organizing and evaluating sound pressure data. A form that can be used for recording data along each vertical traverse is presented in Table 3-1. One of these forms should be completed for each vertical traverse. The primary data for each traverse point are the integrated sound pressure level (column 2) made with linear weighting over all frequencies and a measurement of the sound pressure level (column 4) concentrated in the one-third octave containing the PWMF. These data should be examined for possible "dead" zones within a compartment or for poorly distributed sound. Also, in at least one position within the compartment, a complete one-third-octave analysis should be carried out to confirm that the horn's spectrum is not significantly altered from the ambient tests. An overview of the entire compartment can be plotted by averaging all the readings for the vertical traverses at each measurement position. These data must be converted to pascals before averaging, because decibels cannot be averaged.

Figure 3-3 shows average integrated sound pressure data (Pa) recorded at 16 measurement positions in a typical full-scale baghouse compartment with four horns. The compartment average was 122 Pa, which

was well above the minimum of 80 Pa required for western low-sulfur coal. There was only one measurement position with an integrated sound pressure value below 80 Pa. (See Figure 2-3.)

Monitoring pressure drop and bag weights

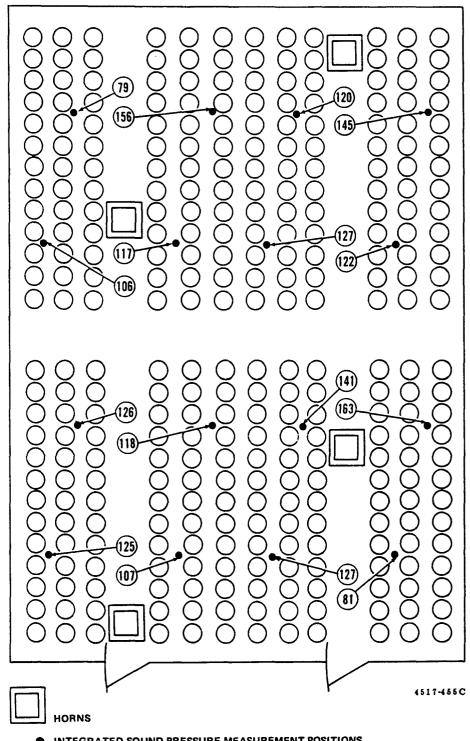
In the third phase of testing, the unit should be brought on-line and pressure drop across the tubesheet should be monitored in the test compartment. Finally, at the conclusion of the test and after about a month of stable operation, bags should be weighed to confirm a reduction in residual dustcake weight. If expected reductions in pressure drop and dustcake weight have not been achieved, it may be necessary to increase the number of horns, to evaluate other horns, or to alter the cleaning cycle. Because of the way that waves combine, average integrated sound pressure will not increase in proportion to an increase in the number of horns. The primary benefit from adding horns would be improvement in the spatial distribution of sound. When testing produces satisfactory results, horns can be installed in all compartments.

Table 3-1

DATA FORM BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL)

| Date: | Compartment | | _ Measurement Position | n: |
|-------------------------------|------------------------|----------------------------------|------------------------|-------------------------------|
| Horn Type: | ··· | Number: | PWMF: | Hz |
| Height Above Tubesheet, ft | Integrated SPL, dB* | Integrated Sound Pressure, Pa | SPL at PWMF, dB* | Sound Pressure at PWMF, Pa |
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Note. This form may be reproduced. *To convert to sound pressure. $p = p_0 \log^{-1}(L_p/20)$



● INTEGRATED SOUND PRESSURE MEASUREMENT POSITIONS

(126) MEASURED INTEGRATED SOUND PRESSURE AT INDICATED POSITION

Figure 3-3. Plan of a typical full-scale baghouse compartment equipped with four horns. The average integrated sound pressure in pascals is indicated for vertical traverses made at 16 measurement positions, with bags installed.

Section 4

Operation and Maintenance

Operation

With little difficulty, controls for horn operation can be integrated into an overall bagcleaning system. Assuming an adequate compressed-air supply is available, operating the horns requires only opening the solenoid valve at each compartment for a specified time interval during the cleaning process.

Timing for horn operation

Laboratory studies have demonstrated that most dustcake removal in each sonic cleaning cycle occurs within the first 10 s of horn operation. Little additional removal occurs after about 30 s.

Other tests have shown the best cleaning is provided by timing the horn to sound during reverse-gas flow. Thus, sounding the horns for 30 s during reverse-gas flow is the recommended procedure. If a mechanical or solid-state timer is connected to the control signal that opens the reverse-gas damper, that signal can be used to initiate operation of the solenoid-operated compressed-air valve at the appropriate compartment.

As is shown in Figure 4-1, using horns with every bag cleaning cycle is usually the most effective way to operate for reducing pressure drop. However, for operation with western, low-sulfur coals, which produce less cohesive ashes than do eastern, high-sulfur coals, horns may not be needed with every cleaning cycle. When horns are installed with new bags in a new or rebagged compartment, it is advisable to delay activating horns until they are needed to reduce pressure drop or dustcake weight. This delay will allow the buildup of a layer of residual dustcake thick enough to achieve efficient particle filtration and avoid high emissions during the startup and conditioning period.

Checking the operation of individual horns

One potential difficulty in horn operation is verifying that all of the horns in a compartment are operating. It is not generally possible to determine whether or not one of several horns is working by listening from outside the compartment. No standard

method for detecting whether individual horns are operating has yet been developed, although one effective approach is to run a length of tubing from the vent hole on

the horn to the outside of the baghouse compartment. Each horn can then be checked by cautiously listening at the vent tube while the horn is activated (6).

Maintenance

Pneumatic, diaphragm-driven horns presently in use are generally very rugged and reliable, requiring no specific maintenance procedures other than inspection of mountings and compressed-air supply lines curing baghouse outages. Over a period of time, however, it may be possible for hardware and fittings to be loosened by the

strong vibrations of the horns. In addition, the metal diaphragms of the horns may fatigue or deteriorate in the flue gas environment over an extended period of operation. There have been no indications, however, that these are likely to become serious problems.

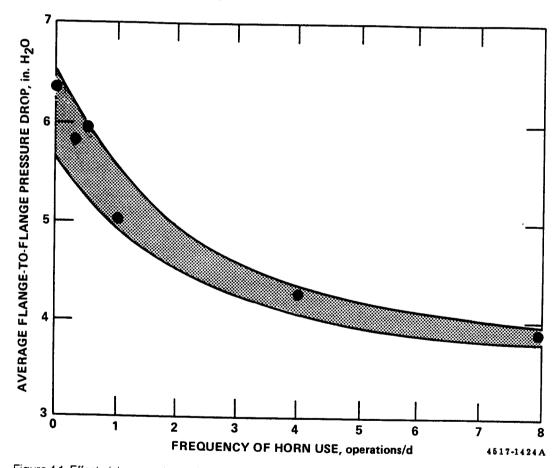


Figure 4-1. Effect of the operating schedule of horns on the pressure drop across a baghouse. In all cases the horns were sounded during reverse-gas cleaning periods. Compartments were cleaned by reverse gas, with or without horns, every three hours.

Section 5

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SECTION EP

DESCRIPTION OF REPORT OF

Appendix A

Fundamentals of Sonic Technology

This appendix contains a detailed discussion of quantitative terms and definitions relative to the fundamental principles of sound. Although it is not essential to have a thorough knowledge of this material to make use of the guidelines manual, this appendix serves as a condensed source of basic information on the theory of sonics and may be helpful in answering some of the reader's questions.

Acoustic quantities may be defined in terms of either logarithmic or linear units. The use of logarithmic units (decibels) arose because of the way the human ear responds to various levels of sound. But the response of mechanical systems to sound pressure are linearly proportional to the amplitude. So in applications where the interaction of sound with matter is to be quantified, linear units of sound pressure (pascals) are more appropriate.

A sound can be characterized in terms of an associated pressure. By definition, sound pressure is the root-mean-square average value of the deviation of the pressure from the ambient level as a result of the passage of a sound. In this document the pascal (Pa), defined as 1 newton per square meter (N/m²), is used as the unit of pressure. (As a point of reference, standard

atmospheric pressure is approximately 105 Pa.). Most of the measurements discussed are in units of pascals, but it is important for the reader to have some acquaintance with the meaning of decibels, because many of the devices used in making sonics measurements are calibrated in these units. Decibels, however, are not units in the conventional sense, nor is their use limited to sonic technology. Consequently, there tends to be considerable confusion in the interpretation of quantities expressed in decibels. The "bel," named for Alexander Graham Bell, is the common logarithm of the ratio of two quantities, one of which is a reference level that is either specified or understood by convention:

$$N(B) = \log(\mathbf{P}_1/\mathbf{P}_0) \tag{A-1}$$

where

N(B) = number of bels

P_o = reference power level

P. = measured power level

This expression indicates that \mathbf{P}_1 is N(B) bels greater than \mathbf{P}_0 . The quantities \mathbf{P}_0 and \mathbf{P}_1 must be in units of power or units that reduce to those of power when expressed as a ratio.

The decibel is simply one-tenth of a bel. Thus Equation A-1 may be rewritten

$$N(dB) = 10 \cdot \log(\mathbf{P}_1/\mathbf{P}_0) \tag{A-2}$$

where

N(dB) = number of decibels

This equation states that \mathbf{P}_1 is N(dB) decibels above \mathbf{P}_0 . A quantity can be expressed in decibels only if a reference level is specified or understood by convention.

Total output power level

The total sonic energy per unit time emitted by a source is the total output power level, which is compared to a reference level of \mathbf{P}_0 = 10^{-12} W. Following the other definitions, then, the total output power level is

$$L(\mathbf{P}) = 10 \cdot \log(\mathbf{P}/\mathbf{P}_0) \tag{A-3}$$

where

 $L(\mathbf{P})$ = total output power level

 $\mathbf{P}_0 = 10^{-12} \,\mathrm{W}$, the reference total output power

P = total output power

Sonic units such as sound pressure can be expressed in terms of decibels with the use

of an appropriate reference level and a suitable adjustment of Equation A-3. Power density can also be expressed in decibels, since division of both **P**₀ and **P**₁ by a unit of area leaves the argument of the logarithm in Equation A-2 unchanged. Similarly, ratios of energy and energy density may be expressed in decibels, since power is a derivative of energy. Decibels are sometimes used to express quantities such as the voltage gain of an amplifier or the rms pressure of a sound wave. In order to do so, however, it is necessary to refer ultimately to units of power. This point will be illustrated by example in the next few paragraphs.

Acoustic intensity and intensity level

Acoustic intensity is the rate of energy transfer through a unit surface normal to the direction of propagation at the speed of sound. Intensity has units of watts per square meter (W/m²). In terms of pressure, the acoustic intensity equation is

$$I = \rho^2/\rho V \tag{A-4}$$

where

I = acoustic intensity

p = sound pressure

 ρ = the density of the gas

v = velocity of sound

Since acoustic intensity is in units of power density and units of area cancel out in a ratio of these quantities, the intensity level can be defined in decibels as

$$L(I) = 10 \cdot \log(I/I_0) \tag{A-5}$$

where

L(I) = intensity level in decibels

10-12 W/m², the reference acoustic intensity

 I_1 = measured acoustic intensity

Sound pressure level

Now, substituting from Equation A-4 for I and I_0 into Equation A-5 and, using the relationship $\log x^2 = 2 \cdot \log x$, one finds that sound pressure level, in decibels, can be derived from units of sound pressure:

$$L(p) = 20 \cdot \log(p/p_0) \tag{A-6}$$

where

L(p) = sound pressure level

The index has been changed to a p, indicating that this equation defines sound pressure level. The expressions for sound

pressure level and intensity can be consistent, however, only if the value of p_0 corresponds exactly with l_0 for a specific sound wave. Equation A-4 indicates that the relationship between these two quantities depends upon the density of the medium and the speed of sound, so instead of defining p_0 in terms of l_0 , which can vary with atmospheric conditions, the reference for p_0 has been designated as 2×10^{-5} Pa. This value is very close to what would be calculated from Equation A-4 if p_0 and p_0 for air at standard temperature (20°C) and pressure (760 mm Hg) were used, and l_0 = l_0 .

Energy density

The energy density due to the passage of sound through a region of space is

$$D = 2\pi^2 f^2 A^2 \rho^2 \tag{A-7}$$

where

D = energy density

f = the frequency of the sound wave

A = the amplitude of molecular

motion

 ρ = the density of the medium

The relationship between energy density and acoustic intensity is simply

$$I = Dv (A-8)$$

A summary of the relationships among the quantities described above is given in Table A-1.

Table A-1 **RELATIONSHIPS AMONG SONIC QUANTITIES**

| Quantity | Level, dB | dB Reference | Definitive Function |
|---|---|-------------------------------------|--|
| Sound Pressure | $L(p) = 10 \cdot \log(p^{2}/p_{0}^{2})$ = 20 \cdot \log(p/p_{0}) | $p_0 = 2 \times 10^{-5} \text{Pa}$ | $\rho = \sqrt{2\pi \rho \sqrt{A}}$ |
| Intensity | $L(l) = 10 \cdot \log(l/l_0)$ | $I_0 = 10^{-12} \text{W/m}^2$ | $I = \frac{D^2}{\overline{\rho_V}} = DV$ |
| Total Output Power | $L(\mathbf{P}) = 10 \cdot \log(\mathbf{P}/\mathbf{P}_0)$ | $P_0 = 10^{-12} \text{ W}$ | $\mathbf{P} = \oint_{s} l ds$ |
| f = sonic frequency, Hz A = sonic amplitude, m P = density of medium, kg/m³ V = speed of sound in the medium, m/s. D = energy density ds = element of surface | | | |

Total output power

The total output power radiated by an acoustic source equals the integral of the intensity over any closed surface containing the source. For a simple example, consider a point source of sound radiating a spherically symmetric wave into an isotropic medium and choose the surface of interest to be a sphere of radius *r* centered on the source. Because of the symmetry of the configuration, the intensity of the sound must be uniform on the surface, and the required integral is simply

$$\mathbf{P} = 4\pi r^2 I(r) \tag{A-9}$$

where

P = total output power radiated by an acoustic source

/ = intensity

r = radius (from source to surface)

Sound intensity, power, and pressure at a specific distance from the source

If it is assumed that the thermal losses are negligible, then in the spherical geometry described above, intensity at any radius is inversely proportional to the square of the distance from the source, that is,

$$I(r) = \frac{I_0 r_0^2}{r^2}$$
 (A-10)

where

 l_0 = the intensity at a reference distance from the source

 r_0 = reference distance from the source

r =any distance from the source

/ = intensity at any radius

Thus.

$$\mathbf{P} = 4\pi r_0^2 I_0(r) \tag{A-11}$$

Example

If a source produced 100 W of acoustic power (140 dB), the intensity at a distance r_0 = 1 m from the source would be

$$I(r) = \frac{P}{4\pi r_0^2} = 7.96 \text{ W/m}^2$$

or, in decibels,

$$L(l) = 10 \cdot \log(7.96 \times 10^{12})$$

= 129 dB

The third quantity, sound pressure, is

$$p = \sqrt{\rho V l}$$
= (1.18 kg/m³ x 330 m/s x 7.96 W/m²)^{1/2}
= 55.7 Pa

Converted to decibels, the sound pressure level is L(p) = 129 dB, agreeing closely with the intensity level, as required by the definitions explained in the paragraph following Equation A-6.

As previously stated, sound pressure values are expressed in pascals throughout this document to describe sonic data. Occasional use of sound pressure level units, or decibels, is required to illustrate specific points. The user of horns should be acquainted with the various terms, since vendors are likely to describe their devices in terms of decibels.

Frequency and sonic spectra

The frequency of a periodic sound wave is the number of times per second a peak value of pressure passes a fixed point. The units of frequency are hertz (Hz), or s⁻¹. As a general rule, frequencies are defined or compared on logarithmic scales, as are other acoustically related quantities. Human auditory response ranges roughly between 20 and 20,000 Hz, and peaks at about 3000 Hz. The frequency is interpreted by the listener as the tone or pitch of a sound.

Some of the definitions related to sonic frequencies are drawn from musical terms. For example, tones differing in frequency by a factor of two are said to be an octave apart, since they are separated by eight intervals of a diatonic musical scale. Any two tones are said to be harmonically related if the ratio of their frequencies is an integer or a simple fraction. Since the octave is the basis for measurement, and the scale is logarithmic, the relationship between two frequen-

cies can be expressed as

$$f_1 = f_0 \cdot 2^n \tag{A-12}$$

where

f = 2nd frequency

 $f_0 = 1$ st frequency

n = the number of octaves separating the two frequencies

Thus, comparing $f_0 = 20$ Hz and $f_1 = 20,000$ Hz, the ratio is 1000, which is almost equal to 2^{10} . So, the range of human hearing can be said to span approximately 10 octaves. The interval defined by n = 1/3 has been found convenient for measuring acoustic spectra. For this interval, $f_1 = 1.260 f_0$.

The integrated sound pressure is not the simple sum of the contributions from each one-third-octave interval. Effects of reinforcement and cancellation complicate the picture. But since the total output power must be conserved, and the power is a function of the square of the acoustic pressure, integrated sound pressure may be expressed as the square root of the sum of the squares of the contributions from the various frequency bands.

Appendix B

Sonic Spectra and Operating Characteristics of Commercial Horns

Several types of commercial horns were characterized by a one-third-octave frequency analysis at the Fabric Filter Pilot Plant at EPRI's Arapahoe test facility. The results of those analyses are shown as sonic spectra on the following pages of this appendix (Figures B-1A through B-1C). The spectral graphs are cut off at 2000 Hz because components at higher frequencies, however intense they might be, would have practically no effect on the removal of dustcake from a filter. In addition, values of PWMF, geometric standard deviation, integrated sound pressure, and compressedair consumption are summarized in Table B-1.

All horns were tested outdoors, well away from acoustically reflective surfaces. During testing, a horn was oriented with its bell pointed upward. The calibrated microphone used for making the measurements was suspended from a thin wooden boom. With this arrangement, the microphone could be positioned along the axis of the bell at any distance up to about 8 m. The sound-pressure-level meter was set on the linear weighting scale for all measurements.

As a general procedure, the microphone was set up as close to the mouth of the horn as possible without overdriving the soundpressure-level meter. Supply air pressure was set at 60 psi for all of these measurements. Normalization of the measurements to a distance of 1 m was based on the assumption that the intensity of the sound is inversely proportional to the square of the distance from the mouth of the horn. This relationship holds true only if the source is spherical, the temperature of the air is uniform in the region of interest, and there are no reflections; it was found experimentally, however, that the inverse square rule was accurate to within about 20% in predicting the sound pressure as a function of distance for various horns.

Note: Data on spectra for the output of commercial horns were obtained using consistent procedures in open-air tests. Horns used in testing were provided by manufacturers as representative of particular models at that time, and copies of these data were provided to the manufacturers. There is no assurance these data accurately characterize horns currently marketed under the same or similar designations.

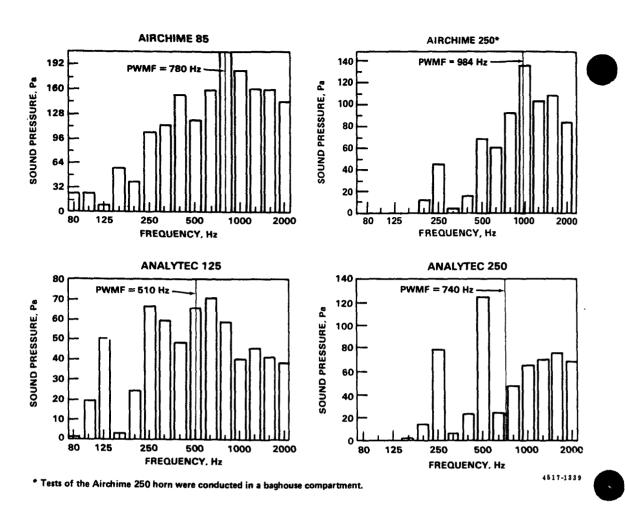


Figure B-1A. Sonic spectra for commercial horns. Measurements were made in free air under identical conditions, to the extent possible, for all horns. Supply air pressure was 60 psi. (See note on page B-1.)

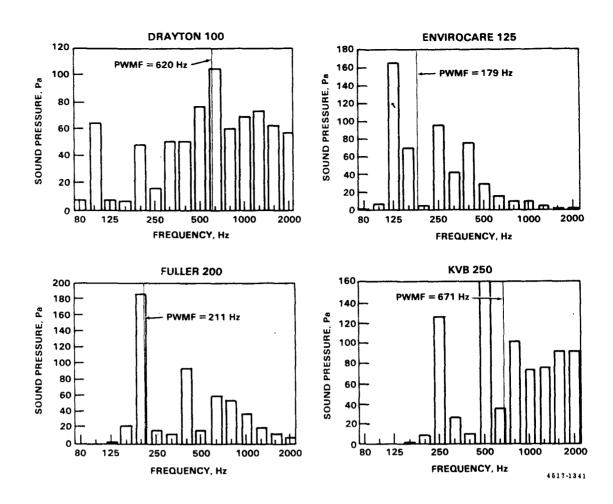


Figure B-1B Sonic spectra for commercial horns, a continuation of the previous figure. (See note on page B-1.)

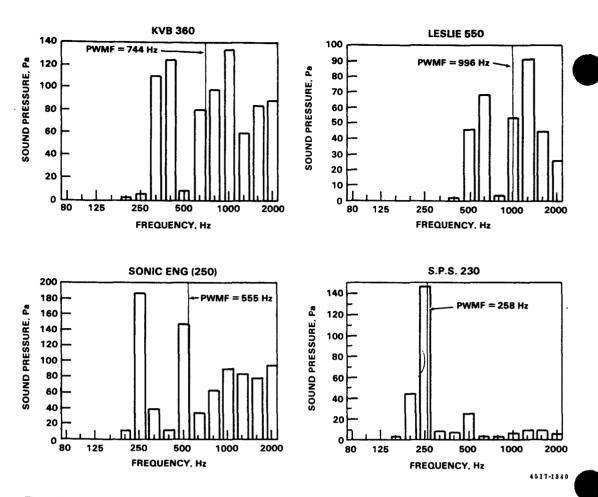


Figure B-1C. Sonic spectra for commercial horns, a continuation of the previous figure. (See note on page B-1.)

Table B-1

OPERATING PARAMETERS OF COMMERCIAL HORNS
AT A SUPPLY AIR PRESSURE OF 60 psi*

| | Fundamental Frequency, Hz | PWMF, Hz | Geometric Standard Deviation | Integrated Sound Pressure (Level), Pa (dB) | Compressed- Air Consumption, scfm |
|----------------------------------|------------------------------|----------|------------------------------------|--|---|
| Airchime | 85 | 780 | 1.87 | 2312 (161.3) | 75 |
| Airchime | 250 | 984 | 1.67 | 272 (142.7) | 50 |
| Analytec | 125 | 510 | 2.08 | 176 (138.9) | 54 |
| Analytec | 250 | 740 | 1.95 | 220 (140.8) | 53 |
| Drayton | 100 | 620 | 2.22 | 352 (144.9) | 54 |
| Envirocare | 125 | 179 | 1.59 | 250 (141.9) | 59 |
| Fuller | 200 | 211 | 1 31 | 116 (135.3) | 33 |
| KVB | 250 | 671 | 1.98 | 390 (145.8) | 132 |
| KVB | 360 | 744 | 183 | 304 (143.6) | 120 |
| Leslie | 550 | 996 | 1.48 | 135 (136.6) | 15 |
| Sonic Engineering Sonic Power | 250 | 555 | 2.12 | 440 (146.8) | 140 |
| Systems | 230 | 258 | _1 26 | 166 (138.4) | 125 |

^{*}Sound pressure and sound pressure level integrated over all frequencies and normalized to one meter, assuming a sound pressure and distance relationship of $p^2(R) = p^2(1)/R^2$, where p is equal to sound pressure and R is the range in meters, from the source.

(See note on page B-1.)

Appendix C

Sound Pressure Distribution

Examples of spatial distribution of integrated sound pressure in full-scale utility baghouses

To characterize integrated sound pressure distribution in full-scale utility baghouses equipped with pneumatic horns, measurements were made at Pennsylvania Power and Light Company's (PP&L) Brunner Island Unit 1 baghouse, Holtwood Unit 17 baghouse, and Sunbury Unit 2A baghouse, and also at the Public Service Company of Colorado's Arapahoe Unit 3 baghouse. Procedures for surveying this distribution of sound in a baghouse compartment were not fully developed when these sets of measurements were made, so they include less detail than would have been recorded with the methods described in Section 3. The results are, nevertheless, illustrative, and examples are included in this Appendix.

In selected compartments of the test baghouses, integrated sound pressure measurements were made at three elevations: 3 ft from the top of the bag, at the middle of the bag, and 3 ft from the bottom of the bag. At each of the four baghouses, sonic enhancement improved dustcake removal, and average pressure drop was reduced to approximately 20 to 50% below the levels recorded when reverse gas alone was used for bag cleaning.

Table C-1

DATA SUMMARY FOR PP&L AND ARAPAHOE SONIC HORN EVALUATION

| Plant | Brunner Island Unit 1 | Brunner Island Unit 1 | Holtwood Unit 17 | Holtwood Unit 17 |
|--|--------------------------|--|---------------------------|---|
| Compartment | 8A | 7A | 43 | 31 |
| Horn Type | Fuller-200 | Fuller-200 | KVB-250 | Fuller-200 |
| Number | 8 | 12 | 2 | 4 |
| Location | top-mounted 30° angle | 8 top-mounted 30° angle 4 under walkways (vertical) | top-mounted (vertical) | 2 top-mounted (vertical) 2 side-mounted (horizontal) |
| Cloth Area/ Horn, ft ² | 3409 | 2273 | 4126 | 2063 |
| Compartment Volume Per Horn, ft ³ | 2851 | 1900 | 3986 | 1993 |
| Avg. Dustcake Weight, lb/ft² | 0.41 | 0.48 | 0.75 | |
| Average Integrated S | Sound Pressure, Pa (ar | nd Sound Pressure Leve | i, dB) | |
| Top Level | 114 (135.1) | 145 (137.2) | 169 (138.5) | 71 (131.0) |
| Middle Level | 89 (133.0) | 117 (135.3) | 113 (135.0) | 67 (130.5) |
| Bottom Level | 99 (133.9) | 120 (135.6) | 73 (131.3) | 57 (129.0) |
| Average | 101 (134.1) | 128 (136.1) | 125 (135.9) | 65 (130.3) |

Brunner Island Unit 1 baghouse

The Brunner Island Unit 1 baghouse has 24 compartments, each of which contains 1264 bags. Twenty-three of the compartments were each fitted with eight 200-Hz Fuller Sonic Generators (PWMF of 211 Hz); one compartment (7A) had twelve 200-Hz Fuller Sonic Generators for test purposes. The horns were installed at an angle of 30° off horizontal, rather than vertically as is common practice. This arrangement was necessary because of limited space at the top of the compartments.

As may be seen in Table C-1, measurements were taken in two compartments: compartment 7A, with 12 horns, and compartment 8A, with eight horns.

Figure C-1 shows, as an example, the complete set of integrated sound pressure measurements in compartment 8A.

In compartment 7A, the average integrated sound pressure was approximately 25% greater than in Compartment 8A. In both compartments, average integrated sound pressure was highest at the top of the bag and higher at the bottom of the bag than at the middle. This nonuniformity in sound distribution was a result of competing mechanisms: the normal decrease in pressure with distance from the source and reflection from the tubesheet.

| Holtwood Unit 17 | Holtwood Unit 17 | Sunbury Unit 2A | Sunbury Unit 2A | Arapahoe Unit 3 |
|---------------------------|---------------------------|---------------------------|------------------------|---------------------------|
| 35 | 42 | 13 | 14 | 4 |
| Fuller-200 | Fuller-200 | Fuller-200 | KVB-250 | Fuller-200 |
| 4 | 2 | 2 | 2 | 2 |
| top-mounted (vertical) | top-mounted (vertical) | top-mounted (vertical) | top-mounted (vertical) | top-mounted (vertical) |
| 2063 | 4126 | 4126 | 4126 | 5605 |
| 1993 | 3986 | 4008 | 4008 | 2768 |
| 0.60 | 0.71 | _ | _ | 0.28 |
| 80 (132.1) | 76 (131.6) | 54 (128.6) | 150 (137.5) | 65 (130.3) |
| 73 (131.3) | 68 (130.6) | 47 (127.5) | 103 (134.2) | 51 (128.1) |
| 53 (128.4) | 40 (126.0) | 44 (126.9) | 81 (132.1) | 36 (125.2) |
| 70 (130.9) | 63 (130.0) | 49 (127.7) | 115 (135.2) | 52 (128.3) |

Holtwood Unit 17 baghouse

The Holtwood Unit 17 baghouse has 14 compartments, each with 90 bags. All of the compartments normally contain 200-Hz Fuller Sonic Generators. During these tests, one compartment was fitted with 250-Hz KVB Acousticlean Horns for comparison.

As the data in Table C-1 indicate, measurements at the site were taken in four compartments: compartment 43, with two 250-Hz KVB Acousticlean Horns; compartments 31 and 35, with four 200-Hz Fuller Sonic Generators each; and compartment 42, with two 200-Hz Fuller Sonic Generators. All horns were top-mounted vertically except those in compartment 31, where two were top-mounted vertically and two were

mounted on opposite sides of the compartment, 11 ft above the tubesheet. The highest average integrated sound pressures—approximately twice as high as in any of the other compartments in this baghouse—were recorded in compartment 43, which was equipped with Acousticlean Horns. This type of horn was less effective than the Fuller horns for dustcake removal and pressure drop reduction, however, because a large fraction of this horn's output is at frequencies too high to be useful for bag cleaning (see Figure B-1b). Pressure drop in compartment 42 was approximately 3.2 in. H₂O, and in compartment 43 it was 4.1 in. H₂O.

Values of integrated sound pressure in compartments 31 and 35, with four Fuller horns, were approximately the same as those in compartment 42, with only two Fuller horns. This is a commonly observed phenomenon; it results from the mechanism by which waves combine. This effect demonstrates that increasing the number of horns in a

compartment does not necessarily produce a proportional increase in average integrated sound pressure. Adding horns can be of some use, especially by improving the uniformity of the spatial distribution, but the output of individual horns is the primary factor affecting overall integrated sound pressure averages.

Sunbury Unit 2A baghouse

The Sunbury Unit 2A baghouse has 14 compartments with 90 bags in each. All of the compartments normally contain 200-Hz Fuller Sonic Generators. During these tests one compartment was fitted with 250-Hz KVB Acousticlean Horns for comparison with the others.

As may be seen in Table B-1, measurements at Sunbury were taken in two compartments: compartment 13, with two

200-Hz Fuller Sonic Generators, and compartment 14, with two 250-Hz KVB Acousticlean Horns. In compartment 14, the average integrated sound pressure was more than twice the average value found in compartment 13. This difference in sound pressure by a factor of two is very similar to that noted in the Holtwood Unit 17 baghouse.

Arapahoe Unit 3

As indicated by the data in Table B-1, measurements at Arapahoe Unit 3 were taken only in compartment 4. Average integrated sound pressure was approximately the same as that in compartments fitted with two 200-Hz Fuller horns at the other bag-

houses tested, but that comparison should not be considered significant, since the compartments are not of the same configuration. As at Holtwood, integrated sound pressure decreased monotonically from the top of the bags to the bottom.

Figure C-1. Integrated sound pressure values (Pa) recorded at 66 positions each on the top, middle, and bottom levels in compartment 8A at Pennsylvania Power and Light Company's Brunner Island Unit 1 baghouse. Similar measurements were made at the three other baghouses characterized.

Appendix D

List of Horn Manufacturers

Airchime Manufacturing Co., Ltd. 1410 Boundary Road Burnaby, B.C., Canada V5K 4V3 (604) 291-8295

Analytec P.O. Box 810 Corrales, NM 87048 (505) 898-9515

Drayton Corporation P.O. Box 820 Jacksonville, AL 36265 (205) 435-3576

Envirocare 7100 Redwood Blvd. Novato, CA 94947 (415) 897-4722

Fuller Company P.O. Box 2040 Bethlehem, PA 18001 (215) 264-6011 KVB Inc. Equipment Systems P.O. Box 19518 Irvine, CA 92714 (714) 250-6200

Leslie Company 401 Jefferson Road Parsippany, NJ 07054 (201) 887-9000

Sonic Engineering, Inc. P.O. Box 8358 Coral Springs, FL 33075 (305) 753-7281

Sonic Power Systems P.O. Box 12785 Shawnee Mission, KS 66212 (913) 888-1929

Note: This list is believed to be comprehensive as of the date of publication of this document. However, other horn manufacturers may exist. Utilities are encouraged to survey the market independently for other potential manufacturers and local suppliers or distributors.

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Appendix C

EPRI Paper

"1990 Update, Operating History and Current Status of Fabric Filters in the Utility Industry"

given at the
"Eighth Symposium on the Transfer and Utilization of
Particulate Control Technology"
on March 20, 1990

1990 UPDATE, OPERATING HISTORY, AND CURRENT STATUS OF FABRIC FILTERS IN THE UTILITY INDUSTRY

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ABSTRACT

In order to keep its member utilities apprised of the status of fabric filtration applied to utility coal-fired boilers, the Electric Power Research Institute, since 1978, has been conducting surveys of the operating and maintenance experience at utility baghouses. This paper presents results from the latest baghouse survey of Canadian and U.S. utilities conducted during 1989. The previous survey was conducted in 1985. Since that time baghouses have been placed in service on approximately 5,250 MW of new utility generating capacity (out of a total of 21,047 MW generating capacity with fabric filtration). Fabric filtration is in use on 4,902 MW of generating capacity where there is some type of flue gas desulfurization system (spray drying, dry injection) upstream of the baghouse. Also, 270 MW of generating capacity have recently come on line where baghouses are used downstream of fluidized bed combustion boilers.

While this recent survey updated previously acquired information on the design of these fabric filter units, the main emphasis was on the operating and maintenance experiences at each of the 101 operating baghouses. These data were acquired through the use of questionnaires mailed to the utilities, telephone inquiries, and plant visits. Data were collected in the following areas: baghouse startup procedures, baghouse shutdown procedures, baghouse operating data (air-to-cloth ratio, pressure drop, temperature, opacity, inlet and outlet dust loading, bag cleaning procedures), bag service life and bag failure data, experiences with sonic horns, and baghouse and ash removal system problems. Tables and graphs summarize and compare the operating and maintenance data collected from this survey.

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INTRODUCTION

The electric utility industry continues to be faced with the requirement of highly efficient particulate control devices downstream of their coal-fired boilers. This requirement is a consequence of the United States EPA's new source particle emission limit of 0.03 lb/MBtu and the current attention placed on the control of fine particles $(PM_{10} \text{ regulations})$ and stack opacity.

The utility industry, through the Electric Power Research Institute, has responded to these constraints by conducting a number of research programs to improve existing technologies and develop cost-effective alternatives which will provide highly efficient particulate control. One of these programs, RP1401, "Reliability Assessment of Particulate Control Systems," developed operating, maintenance, and design databases for both fabric filters and electrostatic precipitators. Summary articles on the fabric filter databases have been reported previously (1,2,3). This paper summarizes the results of the most recent updating of this survey (the last survey update was in 1985). Data have been collected by visiting selected plants and from questionnaires sent to baghouse-operating utilities in the United States and Canada. Utility fabric filters have been in operation for the past seventeen years on stoker-fired, cyclone-fired, and pulverized coal-fired boilers of various designs. In the past five years the number of baghouses operating downstream of pulverized-coal boilers followed by dry FGD systems has increased dramatically. There are also several fluidized bed combustion boilers using fabric filtration for final flue gas cleanup.

Several trends are appearing in the evolution of the fabric filter industry. First, a number of utilities have selected to retrofit sonic horns to assist reverse-gas cleaning at their baghouses. These retrofits have met with success, and it appears that reverse-gas cleaning with sonic assistance is the cleaning method of choice for full-scale, low-ratio utility baghouses on pulverized coalfired boilers. Second, for the past six years the bag failure rate has stabilized

at about 1% per year of the installed bag capacity. Third, there is little, if any, reduction in boiler availability as a direct result of baghouse malfunction. Fourth, baghouses are being successfully employed downstream of dry flue gas desulfurization systems and fluidized bed combustion boilers.

As of December 1989, there were 101 baghouses in operation on utility boilers, representing 21,047 MW of generating capacity (only 2 in Canada, both pulse-jet units). Another four units with a combined generating capacity of 1,150 MW are on order or under construction. Eight units, Bullock 1 and 2 (Colorado Ute Electric Association), Kramer 1, 2, 3, and 4 (Nebraska Public Power District), and North Broadway 2 and 3 (Rochester Public Utility Department), totaling 202 MW, have been permanently retired from service. Several units indicated as planned in 1985 are still in the planning stage or have been canceled. These include Irvington 1, 2, and 3 (Tucson Electric Company), and Coronado 3 (Salt River Project). Survey data were previously reported for two EPRI fabric filter test facilities. The one at Public Service Company of Colorado's Arapahoe plant was decommissioned in 1988. The pilot fabric filter at Gulf Power Company's Scholz plant was reconfigured from reverse-gas cleaning to pulse-jet cleaning in 1989. EPRI also has a small reverse-gas cleaning fabric filter pilot plant at its High Sulfur Test Center located at New York State Electric and Gas Company's Somerset Station.

Utility plants using fabric filters range in size from 6 MW at Marshall Unit 4 to 860 MW at Sherburne Unit 3. The largest operating baghouses (19,872 bags per unit) are the two 739 MW units at Four Corners. The oldest operating installation, Sunbury, was commissioned in 1973.

Figures 1 and 2 present, respectively, new utility fabric filter installations by year and the cumulative megawatt capacity of operating units for 1973 through 1989 with the projection of new capacity through 1992 based on units in design or under construction. Data in Figure 2 are shown separately for low-ratio baghouses downstream from pulverized-coal boilers and for low-ratio baghouses downstream from pulverized-coal boilers utilizing dry FGD processes because of their large percentage (23%) of total megawatt capacity (4,902 MW out of 21,047 MW). The sharp rise in baghouse utilization beginning in 1978 reflects the impact of NSPS legislation in 1979.

Coals burned in boilers equipped with baghouses are: anthracite, eastern and western bituminous, western subbituminous, and Texas and North Dakota lignites. Sulfur contents for these coals average 1% and range between 0.3% and 3.5%.

Figure 3 shows the megawatt capacity of fabric filter installations in each state of the continental United States. The greatest concentration of fabric filters is clearly in the southwest. Although Colorado has the greatest number of installations, 16, Texas has the most installed capacity, 5341 MW.

FABRIC FILTER DESIGN DATA

Design data for utility fabric filters in operation, under construction, or in the engineering phase have been updated. Of the 101 baghouses now operating, 59 are reverse gas, 30 are reverse gas with sonic assistance, 9 are shake/deflate, and 3 are pulse jet cleaning designs.

The largest baghouses (Four Corners 4 and 5, Intermountain 1 and 2, and Sherburne 3) have 48 compartments. The largest number of bags per compartment is 648 at North Valmy 1. Bag sizes are commonly 8" diameter by 22' to 24' in length or 12" diameter by 30' to 35' in length. Figure 4 shows the distribution of fabric filters by baghouse manufacturer based on installed MW capacity.

Bag material in the installations surveyed is mostly woven glass fiber. Fabric coatings include Teflon B, silicon graphite, and proprietary acid-resistant materials. Bags are attached to the tubesheet by means of thimbles, typically of a length identical to the bag diameter. The thimbles protect the bottom of the bags from erosion by fly ash where its flow is most turbulent. Bags are attached to the thimbles by means of slip rings sewn in the bottom cuff or by screwtightened clamps.

Most units are designed for easy access to allow for inspection and bag replacement. For most installations, the bag replacement time is 15 to 30 minutes per bag for two men. Most units have insulation between compartments, as well as ventilation systems to cool compartments quickly and permit personnel to work comfortably and safely while the rest of the baghouse remains in service.

FABRIC FILTER OPERATION AND MAINTENANCE DATA

During 1989 questionnaires were sent to all domestic and Canadian utilities with operating baghouses to obtain performance, operation, and maintenance data. To support this effort, special site visits were made to fifteen of the larger low-ratio baghouses (all in the U.S.), representing 10,627 MW of generating capacity. There were special areas of interest including bag service life, bag

failure rates, coal and ash data, pressure drop histories, emissions data, maintenance problems, and major component failures. Some utilities have had several years of operating experience while others have had only a few months, thus the comments and problems listed in the completed questionnaires were indicative of both short- and long-term operation and maintenance concerns.

Efficiency, Emissions, and Opacity

Design efficiencies for baghouses range from 98.00% to 99.91%. Most units meet or exceed their design efficiencies. A number of plants are reporting outlet mass emission rates significantly less than the NSPS of 0.03 lb/MBtu. These data are shown in Figure 5. None of the plants that have retrofitted sonic horns to assist reverse gas cleaning report any deterioration in baghouse efficiency, when the sonic horns are used properly. All plants visited reported stack opacities of 1 to 5%, well within the legal limits.

Pressure Drop

Pressure drop continues to be an area of major interest to utilities since fan power is costly. High pressure drop can also contribute to shorter bag life due to the additional cleaning cycles that the fabric must endure. The highest reported flange-to-flange pressure drops for 1989 were 11 to 12 inches H_2O (Texas lignite coal, shake/deflate cleaning, 1.7 acfm/ft² air-to-cloth ratio) and 6.0 to 8.0 inches H_2O (western subbituminous coal, shake/deflate cleaning, 3.2 acfm/ft² air-to-cloth ratio). The lowest value was 3.5 inches H_2O (anthracite coal and petroleum coke, reverse gas cleaning with sonic assistance, 1.9 acfm/ft² air-to-cloth ratio). The flange-to-flange pressure drop generally falls between 4 and 8 inches H_2O . At most plants the difference between flange-to-flange pressure drop and tubesheet pressure drop was 1 to 2 inches H_2O . At one plant a difference of 3 inches H_2O or greater was observed.

According to the latest survey results, there is an even split between installations using intermittent cleaning and continuous cleaning. Intermittent cleaning is defined as time-dependent cleaning where the compartments are cleaned sequentially with a short dwell period between cleaning one compartment and the next. A longer dwell period between cleaning the last compartment and the start of a new cycle can be overridden when baghouse differential pressure becomes greater than some limit. Continuous cleaning can be initiated on either time or pressure drop set point; it cleans one compartment after the other sequentially, without dwell.

In the report on the previous survey data (3), weighted average pressure drop* data were reported for the years 1980 through 1984. This same analysis has been performed for pressure drop data reported in 1989. Data from 33 plants representing 9,833 MW of generating capacity were used. The weighted average was 6.3 inches H_2O . These data are combined with the previous data in Figure 6.

Sonic Horns

Seventeen baghouses since the last survey in 1984 have had sonic horns installed to help maintain a lower baghouse pressure drop. Reported pressure drop reductions are from 1 to 3 inches $\rm H_2O$. The data indicate that several plants use the horns only to recover from high pressure drop excursions; one plant even uses one as a mobile device to be carried from compartment to compartment. One plant uses sonic assist only intermittently, once or twice a day, and not during every cleaning cycle. Based on the responses from the plants, it appears that each plant develops it own criteria for frequency of horn use. One plant may require assistance with each cleaning cycle, while another may need sonic assist only in times of high pressure drop excursions.

Bag Failures

Approximately 70% of the reporting units had fewer than 50 bag failures in 1989. Reported causes of bag failures are abrasion, acid attack, poor manufacture, and improper tensioning. Most installations report bag failure at random locations within each baghouse compartment and within the baghouse as a whole. However, bag failures are largely limited to the lower half of the bag, often near the thimble.

Bag failure rates have been fairly steady at about 1% of installed bags per year for the last six years, as shown in Figure 7. In 1989, 1528 failures were reported out of a total of 132,772 bags, for a failure rate of 1.2%.

$$\frac{\sum_{i=1}^{N} (\text{Number of bags})_{i} \times (\text{pressure drop})_{i}}{\sum_{i} (\text{Number of bags})_{i}}$$

where i runs over each unit reporting pressure drop and N is the total number of baghouses reporting pressure drop in each year.

^{*}Weighted average pressure drop is defined as:

Bag Service Life

Data obtained from the survey questionnaires and the site visits to selected plants have allowed the preparation of graphs showing bag service life history (years in service before replacement) for low-ratio baghouses filtering flue gas from utility pulverized-coal-fired boilers. Figure 8 shows the service life for bags downstream from low-sulfur and high-sulfur coal boilers. The data represent information for 95.0% of the low-ratio baghouses installed on utility pulverized-coal-fired boilers (based on megawatt generating capacity). The mean service life for bags on low-sulfur coal boilers is 5.2 years. The mean service life for bags on high-sulfur coal boilers is 3.3 years. These data represent bag service life; since many utilities rebag when cumulative failures reach 10%, it is likely that many bags are removed from service prior to actual failure and could have remained in service for an unknown number of additional years.

Coal Characteristics

Figure 9 presents the breakdown of coal types burned at plants utilizing fabric filters. As can be seen, the most common coal type by far is western subbituminous, used in 62.3% (13,112 MW) of the total generating capacity of utility boilers using baghouses. This is a natural result of the large fraction of baghouses located in the western United States.

Baghouse Maintenance Experience

The types of problems reported in 1989 are similar to those obtained from earlier surveys. Some baghouses continue to experience stratification of dust loading from the front to the back of the baghouse, as well as within specific compartments. Generally the heavier loading occurs in the compartments near the back of the baghouse. One plant noted severe stratification of dust loading within compartments.

Many of the plants continue to have problems with poppets, valves, and their operators. Typical responses include failed limit switches, seal leakage, spider guide breakage, shear pin failure, improper seating of poppets, corrosion, ash buildup on poppets, valve stem guide wear, sticky or sluggish operation in cold weather.

There were fewer reported problems with reverse gas fans in 1989. Two plants reported that their installed fans provided marginal capacity, while another plant reported severe corrosion with their ductwork and fans.

Baghouses designed in 1979 and later are generally equipped with microprocessor controls for baghouse operation. These controls perform very reliably. Most of the questionnaires received in 1989 reported few problems with their systems. Some plants reported problems due to condensation in control air lines.

A number of plants reported problems with expansion joints, the highest incidence occurring with the reverse gas system. This problem is probably due to cooler temperatures leading to corrosion and the increased flexing that these systems must endure.

Corrosion continues to be a problem at several plants, especially in the reverse gas system. Another typical site for corrosion is compartment doors where inleakage occurs as a result of improper or worn gasket material.

Several plants reported problems with their bag tensioning mechanisms. The most common problem was with improperly sized springs that collapse under moderate bag weight and allow the bags to cuff at the thimble. Most of these plants have replaced their springs.

The variety of maintenance problems points out one of the strong impressions from the plant visits conducted during this survey. Baghouses that were performing well were usually located at plants where considerable effort was taken in monitoring baghouse operation. If problems arose, fixes were quickly implemented. In contrast, problem baghouses appeared to have little attention paid to them. Corrections of problems occurred only during normal outage periods or if plant availability was threatened.

Baghouse Availability

Most installations report little, if any, reduction in boiler availability as a direct result of baghouse malfunction, indicating that problems are such that they can be corrected in service or during outages for other plant equipment.

Operation and Maintenance Costs

Few of the questionnaires returned in 1989 contain complete operation and maintenance cost data. Respondents generally do not isolate fabric filter system costs from those of related systems.

ASH HANDLING SYSTEMS

Most baghouses use a vacuum system combined with dry storage. The remainder are either combination vacuum/pressure systems or are unidentified. Most units have hopper level detectors of either nuclear or capacitance probe design. Of the 82 units for which data are available, 52 (63%) have hopper heaters. Of the 73 units for which data are available, 21 (29%) have hopper vibrators and warm air fluidizers.

In 1989 few problems were reported with the vacuum producer or blower and the level detector and hopper fluidizer. One plant reported that their entire ash system is at the end of its useful life and will have to be replaced. Minor problems were reported with line and hopper plugging. In general, typical problems with ash removal systems were due to normal wear and usage.

SUMMARY AND CONCLUSIONS

Data have been collected on 113 fabric filter installations. These are distributed as follows:

- --97 in operation
- -- 4 on auxiliary status
- -- 8 retired
- -- 4 in design or construction

Of the 97 fabric filters in operation, 63 units are low-ratio units downstream from pulverized coal-fired boilers using reverse-gas cleaning or reverse-gas cleaning with sonic assistance, 5 are low-ratio baghouses downstream from pulverized-coal fired boilers using shake/deflate cleaning, 2 are pulse-jet cleaned baghouses downstream from pulverized-coal fired boilers (Canadian only), 15 are low-ratio baghouses downstream from dry FGD systems on pulverized-coal fired boilers, 2 are low-ratio baghouses downstream from fluidized bed combustion boilers, 9 are low-ratio baghouses downstream from stoker-fired boilers, and 1 is a pulse-jet cleaned baghouse downstream from a stoker-fired boiler.

There has been a significant increase in the number of installations retrofitted with or designed with sonic assistance for reverse-gas cleaning. Thirty plants report sonic horns installed in their baghouses. Reported improvement in pressure drop from the use of sonic assistance ranges from 1 to 3 inches of water.

Most installations report very high collection efficiencies for their baghouses, generally greater than 99%. Of the reporting plants, 85% had mass emission rates of 0.03 lb/MBtu or less. At the plants visited during this survey operating stack opacities were in the range of 1 to 5%, significantly better than legal requirements.

Flange-to-flange pressure drop ranged from a high of 11 to 12 inches of water to a low of 3.5 inches of water. Typically the range was from 4 to 8 inches of water for the plants reporting data. The weighted average pressure drop for 1989 was 6.3 inches of water, similar in magnitude to those values previously reported for the years 1980 through 1983.

Approximately 70% of the reporting units had less than 50 bag failures in 1989. The average bag failure rate has rémained steady at about 1% of installed bag capacity for the last six years. Typical causes for bag failure continue to include abrasion, improper tensioning, poor manufacture, and acid attack.

Bag service life is generally impressive considering the concern about bag life when fabric filters were first being installed on utility boilers. The mean service life of bags installed in low-ratio baghouses on low-sulfur pulverized coal boilers has risen to 5.2 years. The mean service life of bags in low-ratio baghouses on high-sulfur pulverized-coal boilers is 3.3 years.

Operating and maintenance problems are not confined to any specific area. The most common problem areas in 1989 were valves and valve operators, bag tensioning mechanisms, expansion joints, and reverse gas fan systems. Problems associated with ash handling systems appeared to be associated with normal wear on the components.

Baghouses have continued to maintain high availability factors and were seldom, if ever, a cause for boiler down time. Baghouses continue to demonstrate that they are efficient, reliable, and cost effective particulate control devices for the utility industry.

ACKNOWLEDGMENTS

The authors wish to thank the many utilities that responded to the 1989 survey questionnaire, providing accurate and up-to-date information on baghouse operation and maintenance. The authors are especially grateful to the following plants that allowed on-site visits to obtain survey data: Bonanza, Brunner Island, Cherokee, Four Corners, Harrington, Hunter, Intermountain, Monticello, North Valmy, Nucla, Parish, Reid Gardner, Sammis, and Tolk. This work was performed under EPRI Contract RP1129-8.

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- 2. W. Piulle, R. Carr, and P. Goldbrunner. "1983 Update, Operating History and Current Status of Fabric Filters in the Utility Industry." <u>Proceedings: Second Conference on Fabric Filter Technology for Coal-Fired Power Plants</u>. CS-3257. Palo Alto, California: Electric Power Research Institute, November 1983, p. 1-1.
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Utility Fabric Filter Installations

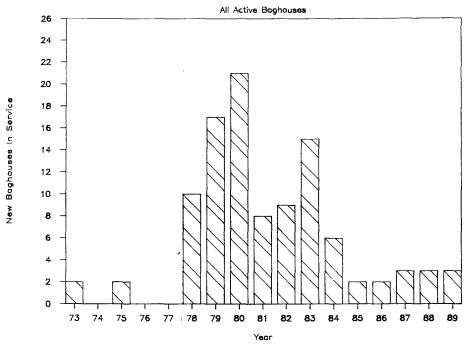


Figure 1. The number of new utility baghouses placed in service during each year beginning in 1973.

Cumulative Megawatt Capacity

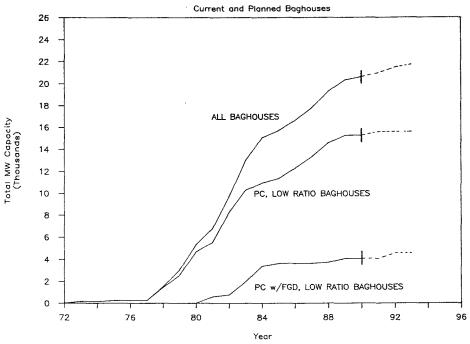


Figure 2. Chronological history of cumulative megawatt capacity of utility baghouses. Data are presented for all baghouses and separately for low-ratio baghouses downstream from pulverized-coal boilers and low-ratio baghouses downstream of dry FGD systems on pulverized-coal boilers. Data for baghouses in design or construction are shown beyond 1989.

Total Megawatt Rating of Stations with Fabric Filters in the United States

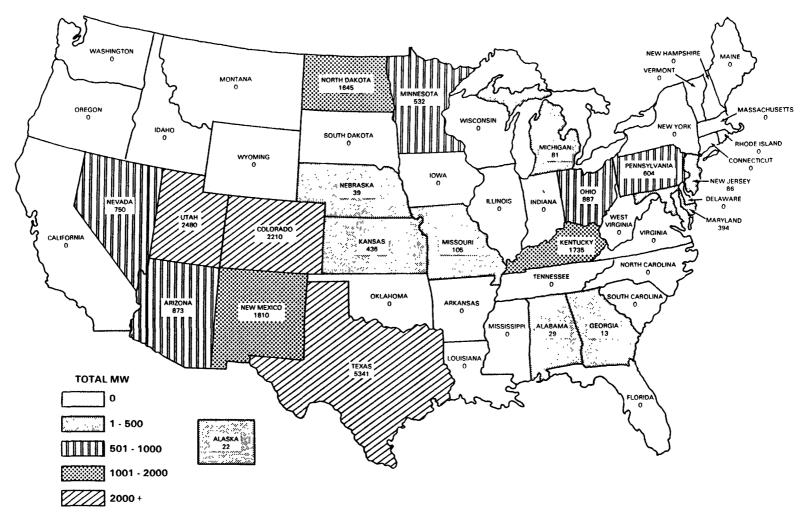
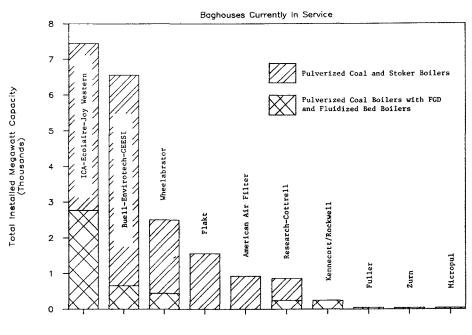
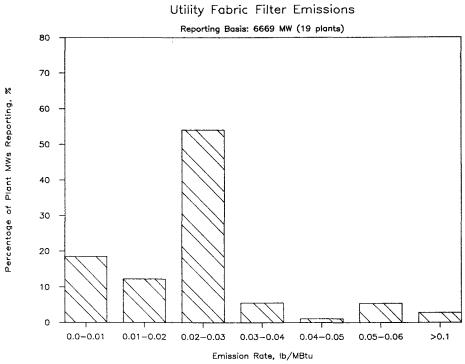


Figure 3. Distribution of utility baghouses currently in service by state (based on total megawatt generating capacity).

Fabric Filter Manufacturers



Monufacturer
Figure 4. Distribution of currently installed utility fabric filters in the United States and Canada by manufacturer (based on total megawatt generating capacity).



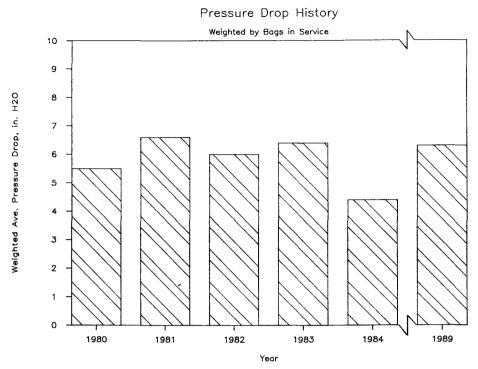
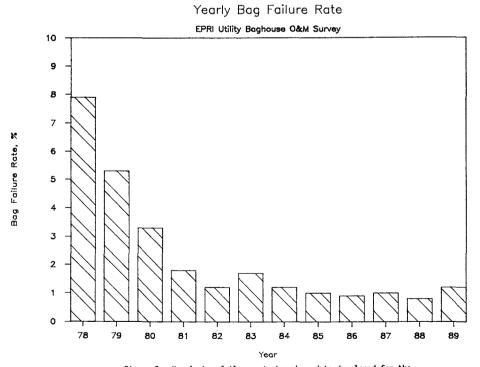


Figure 6. Weighted average flange-to-flange pressure drop for utility baghouses for six years during the 1980's. Weighted average is based on the number of bags in each baghouse having indicated pressure drop. No data are available for 1985 through 1988.



History of Used Bags

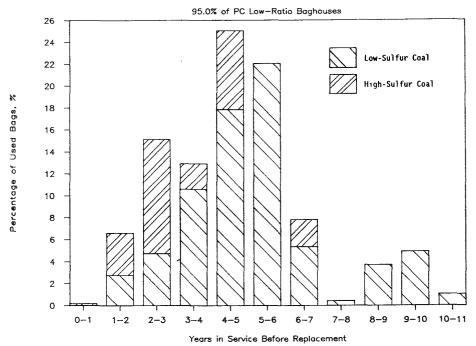


Figure 8. History of used bags on low-ratio baghouses downstream from utility pulverized-coal boilers in the United States. Data are shown individually for low- and high-sulfur coal boiler installations.

Types of Coal Used Percentage Based on MW Rating

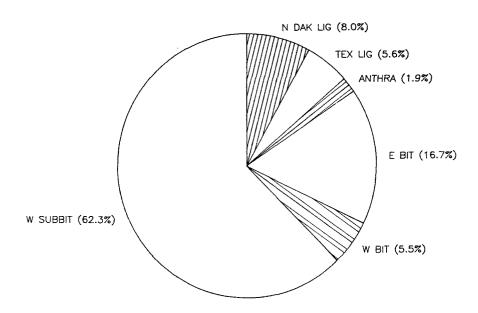


Figure 9. Types of coal used in utility boilers using fabric filters. Percentages based on megawatt generating capacity.

Appendix D

BHA Group, Inc.'s AH-25 Sonic Horn Information and Installation Drawings

Acoustic cleaning theory & application

General Overview

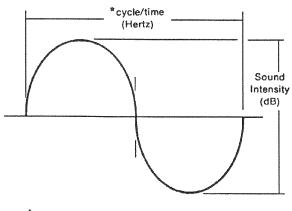
An acoustic cleaning system can provide significantly improved cleaning for air pollution control equipment, material storage equipment and many areas of production equipment where particulate build-up can occur. In most cases, the installation of an acoustic system can:

- improve plant production by maximizing equipment performance
- decrease inflated energy costs due to high baghouse pressure differentials
- Decreasing maintenance expense caused by excessive material build-up.

Acoustic Energy

Acoustic energy is created when sound waves produced by a diaphragm within the driver of an acoustic horn displace the air through which the sound waves pass. The measurable energy produced by these sound waves is dependent on two important parameters. The first is the fundamental frequency of the sound which is measured in hertz (Hz). Each horn has a range of frequency response, or a sound spectrum. It is important to note when discussing acoustic horn output that the fundamental frequency is the lowest frequency in the spectrum and not the greatest percentage of frequency. The second parameter of acoustic energy is the "loudness", or intensity of the fundamental frequency which is referred to as the sound pressure level (SPL), and is measured in decibels (dB).

Below is a diagram illustrating the concepts of hertz and decibels. As illustrated, the number of times a sound wave passes above and below a zero reference line in one second defines the frequency (Hz) or pitch of the sound (Fig. 1). The height of the sound wave above and below the zero reference line defines the intensity or volume of the sound, and is measured in decibels (dB) (Fig. 2).



*(i.e., cycles/time = 120 cycles/second or 120 Hz)

Fig.1 Fundamental Frequency

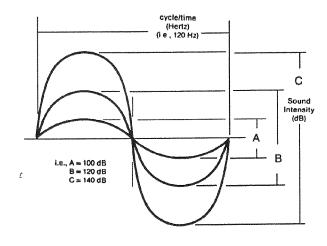


Fig. 2 Sound Intensity

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How Acoustic Horns Work

Acoustic horns are scientifically designed generators which produce high pressure acoustic energy levels within a controlled frequency band. Utilizing an external compressed air source (70-90 PSIG), a high strength diaphragm contained within the driver section of the horn vibrates, producing acoustic pressure energy. This audible acoustic pressure energy is sufficient to break the bond structure of particulate adhering to various surfaces and provides an efficient method of cleaning.

As previously stated, acoustic horns are described in terms of hertz and decibel output which determine the sound pressure level (SPL) of acoustic energy that a horn generates. Lower frequencies carry a longer wave length than higher frequencies and have a greater impact on the surfaces with which they come in contact. For example, an acoustic horn producing 130 Hz, fundamental frequency at 135 dB has a much greater effect on dust particulate than does an acoustic horn producing 270 Hz at the same 135 dB sound pressure level.

Using the prior example, it could be deduced that even though the two horns are operating at the same intensity (135 dB), the horn that is producing the higher frequency (270 Hz) is transmitting acoustic energy that is less effective in moving particulate. This does not necessarily mean that the lower the frequency, the better. There is a point at which acoustic energy can become destructive to solid structures and mechanical connections, and has been proven ineffective on dust particulate. This occurs in the range below 60 Hz.

The intensity of acoustic horn output is an important factor in terms of cleaning effectiveness. However, acoustic intensity levels of a horn expressed as decibels can be deceiving. Even though decibels increase only slightly, the acoustic power produced increases dramatically. As an example, a change from 120 dB to 140 dB is only a 17% increase in decibel level, but a 100-fold increase in acoustic power.

Horns are properly rated at a fundamental frequency (Hz) and a given volume (dB). This can be misleading when specifying cleaning performance due to the sound spectrum of horn output. When a horn is rated as having a certain fundamental frequency, it is important to determine what percentage of its energy in decibels is at its fundamental frequency. Because the energy is rated at the total hertz range output, a horn that appears to be within performance specifications may not produce the necessary sound pressure level at the fundamental frequency needed for cleaning. Its publicized fundamental frequency may only be a small percentage of its sound spectrum and the decibel rating may actually be at a higher, less desirable frequency. (The product may sound loud to the human ear, but the actual energy needed at the fundamental frequency for effective cleaning may never be reached.)

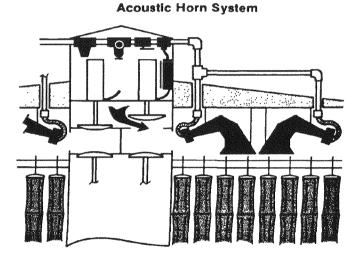
Applications of Acoustic Horns Baghouses

Baghouses

In baghouses, fabric filters build a residual dust cake. Since the filter obstructs airflow, the static pressures on each side of the filter differ. This differential pressure (DP) or pressure drop is directly related to the amount of dust collected on the filter. As the filter dust cake grows, differential pressures climb.

A full system of horns generating a relatively low frequency will remove additional dustcake from the filter bag which lowers overall pressure drop. Studies have shown that a fundamental frequency of 125 Hertz is the most effective in the cleaning of fabric filters. This frequency at a high tubesheet average of 135 decibels causes a larger mechanical movement or vibration, allowing additional dust cake removal.

An acoustic horn system can provide significant benefits in several areas of baghouse performance. Properly installed acoustic horns are capable of reducing pressure differential and increasing system operating volumes. As compared to traditional cleaning methods, the acoustic cleaning process is more gentle and uniform which reduces stress placed on the bags. By lowering overall pressure drop, the frequency of



cleaning can be reduced which also reduces stress on the bag and consequently, extends bag life.

Acoustic horns have been applied to other types of equipment with favorable results. In addition to baghouses, acoustic horns have been successfully used in these applications with the following benefits:

Electrostatic Precipitators

- collector plate cleaning electrode wire cleaning
- gas distribution device cleaning low velocity inlet cleaning

Fans

• dislodgement of particulate buildup on housing and fan rotors

Silos & Bins

maintain free-moving material flow
Eliminates sidewall buildup
Eliminates ratholing

Conditioning Towers & Spray Dryers

• break up of agglomerates on internal walls

Ductwork

Summary

BHA's acoustic horns offer the following advantages:

- 125 Hz fundamental frequency produces more vibration for better cleaning
- 70% of 149 dB output is at 125 Hz, this produces the highest sound pressure level (SPL) available (AH-25)
- Fewer horns necessary per compartment or more square feet of cloth area per horn
- Fabricated carbon steel components are structurally superior to cast components
- Longer diaphragm life
- · Less compressed air consumption for higher output
- No comparable horn in the industry

The installation of a BHA Acoustic Cleaning System is an effective means of enhancing the performance of conventional air pollution control equipment. We at BHA believe that our knowledge and experience will assure you of obtaining the best engineered acoustic cleaning system for your specific application to optimize cleaning performance and in turn, lengthen parts and equipment life. Additional information on our acoustic products can be found on pages 17-24 of our BHA Reference Catalog.



Acoustic Horns enhance reverse air cleaning

A Midwest sugar manufacturer was having problems with their boiler used to process sugar beets. Plant production was often limited by the boiler's inability to reach a high load. During normal operation, the boiler only reached a maximum of 160,000 lbs. per hour of steam even though its rated capacity was 210,000 lbs. per hour.

Careful examination of the problem revealed that boiler load was limited by inadequate airflow through the baghouse caused by high differential pressures. After consulting with BHA Group, Inc., it was suggested that the customer install acoustic horns to assist the reverse air cleaning mechanism. The objective was to reduce the pressure differential to a manageable level which would enable the fan to pull sufficient airflows through the baghouse.

Based on BHA's recommendation, the customer installed a system of AH-20 horns on his industrial boiler baghouse which immediately lowered the differential pressure to 4" w.c. An upset condition in another boiler baghouse required increasing airflow through the baghouse equipped with the horn system. Even though the dramatic increase in airflow was outside normal baghouse design parameters, differential pressure through the collector remained at 4" w.c. Since the horn installation, the customer has been running at 190,000 lbs. per hour which is all he has found he needs—that's a 15% increase over previous boiler load capacity!

To determine what lower pressure drops and extended bag life can do for your bottom line, contact BHA Group, Inc. for a free payback analysis on an acoustic installation. Further information on acoustic horns can be found on pages 17-24 in the BHA Reference Catalog or call us toll free at 1-800-821-2222.

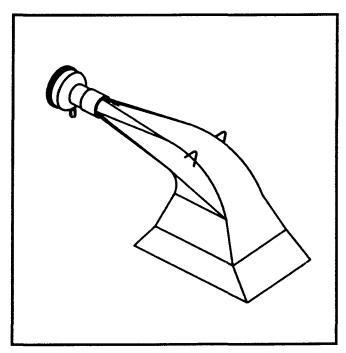






Advanced Acoustic Horn Technology

The AH-25 is rated as one of the most powerful horns available. With 149 decibels of power and a unique bell design for enhanced sound, BHA's patented AH-25 is engineered for large structural baghouses and storage silos to provide greater cleaning efficiency and material movement. Design-engineered and field proven, the AH-25 delivers maximum acoustic energy to help lower differential pressures, increase airflows and improve the overall performance of your air pollution control or material storage equipment.



AH Series Acoustic Horn Model AH-25

Model AH-25*Specifications/Dimensions

Frequency: 125 Hz Power Weighted Mean Freq. 137 Hz Sound Pressure Level: 149 dB

Material: A36 Carbon Steel

(stainless steel available)

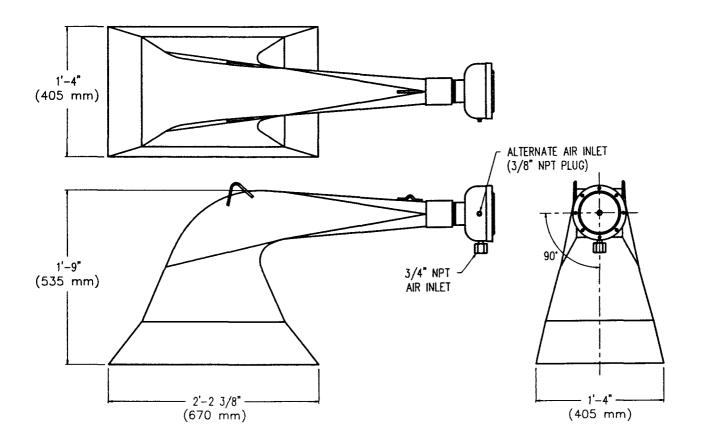
Max. Operating Temp: 650°F (350°C)
Weight: 110 lbs. (50 kg)
Air Consumption: 75 SCFM @ 75 F

75 SCFM @ 75 PSI (35 I/s @ 6,2 bar)

Applications: Structural baghouses,

storage silos

* Patent Pending

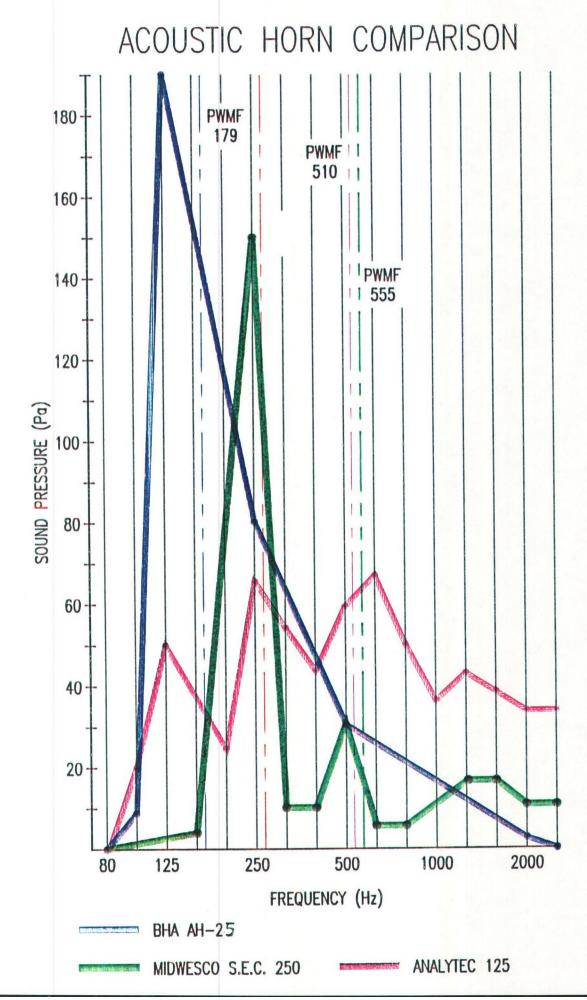


For information on how acoustic horns and accessories can help your specific application, call us toll free:

1-800-821-2222

Group, Inc

8800 East 63rd Street, Kansas City, MO 64133 Phone: 816/356-8400 • Fax: 816/353-1873



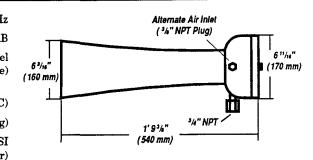
FILE: 25-SEC-A



Acoustic Specifications and Dimensional **Drawings**

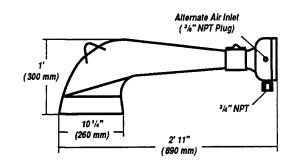
AG-20-A* Specifications:

| Fundamental Frequency (Hertz): | 160 Hz |
|--------------------------------|--|
| Output Power Level (decibels): | 140 dB |
| Material: **(Stair | A36 Carbon Steel iless steel available) |
| Maximum Operating Temperature: | 650° F (350° C) |
| Weight: | 30 lbs. (13,6 kg) |
| Air Consumption: | .45 SCFM @ 45 PSI (21 l/s @ 4.1 bar) |



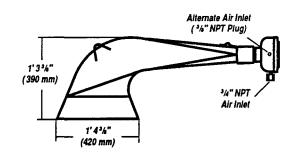
AH-10* Specifications:

| Fundamental Frequency (| Hertz):125 Hz |
|--------------------------------|--|
| Power Weighted Mean Fre | equency:193 Hz |
| Output Power Level (decib | oels): 142 dB |
| | A36 Carbon Steel **(Stainless steel available) |
| Maximum Operating Temperature: | 650°F (350°C) |
| Weight: | 40 lbs. (18 kg) |
| Air Consumption: | 50-60 SCFM @ 55 PSI (23-28 l/s @ 4,8 bar) |



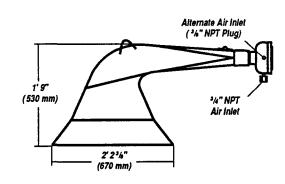
AH-15* Specifications:

| Fundamental Frequency (Hertz): | 125 Hz |
|--------------------------------|---|
| Power Weighted Mean Frequency: | 169 Hz |
| Output Power Level (decibels): | 145 dB |
| Material:**(Stainle | .A36 Carbon Steel ess steel available) |
| Maximum Operating Temperature: | 650° F (350° C) |
| Weight: | 70 lbs. (32 kg) |
| Air Consumption: | 55 SCFM @ 65 PSI (31 l/s @ 5,5 bar) |



AH-25* Specifications:

| Fundamental Frequency (| Hertz):125 Hz |
|--------------------------------|---|
| Power Weighted Mean Fre | equency:137 Hz |
| Output Power Level (decil | oels):149 dB |
| | A36 Carbon Steel **(Stainless steel available) |
| Maximum Operating Temperature: | 650° F (350° C) |
| Weight: | 110 lbs. (50kg) |
| Air Consumption: | 75 SCFM @ 75 PSI (35 l/s @ 6.2 bar) |

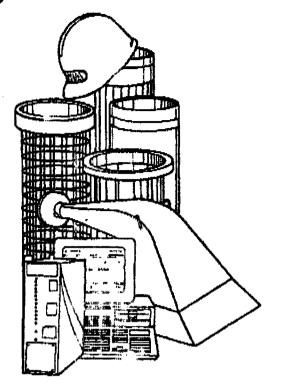


**Note: For higher temperatures or

* Patent Pending

ion resistance, horns can be factured from various alloys.

1-800-821-2222





FAX Cover Sheet

| Date: July | 7 23,1990 |
|----------------|-----------------------------|
| | Payne |
| То: | |
| Company: | Intermountain Power Service |
| FAX number: | 801-864-4970 |
| Number of page |) |
| Reference: | Acoustic Horn testing |

Message:

Jeff, Please confirm an order # for these materials for our records. You will be acknowledged but not invoiced unless you plan on keeping the horns. Materials shipped on July 20, via NW Transport (Pro # 037315669) to be delivered by Wednesday 7/25.

Please accept the following prices per your request for quote:

| Qty | Description | Part Number | <u>Sel1</u> |
|-----|----------------------------|-------------|-------------|
| 5 | AH-25 Acoustic Horn | 822-0158 | \$1,785.00 |
| 5 | Stainless Steel Flex Hose | 822-0053 | \$96,00 |
| E . | 3/4" Full Flow Ball: Valve | 822-0050 | \$58.00 |
| 5 | Hanger Assembly, 9' Chain | 822-0137 | \$85.00 |
| 7 | Pneumatic Line Strainer | 822-0346 | \$15.00 |
| 1 | 1 1/2" Full Flow Ball | 822-0066 | \$96,00 |
| | Valve | | |
| * | 1 1/2" Full Flow Solenoid | 822-0057 | \$274.00 |

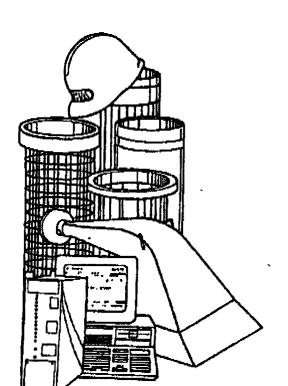
above items are F.O.B. Slater, MO. Terms are net 30.

Note: Ireliminary installation drawings will be forwarded via telefax for your review by Wednesday July 25th. Please look over and contact me if you have any questions. I will then finalize the drawings and send a formal package to you.

INTERMOUNT/QTXTLG/SS

Mcleod Stephens 816-356-8400 ext 375 FAX: 816-353-1873

TOTAL P.01.





FAX Cover Sheet

| Date: | 6/27/90 | |
|-------------|----------------|--|
| То: | JEFF PAYNE | 1 |
| Company: _ | IPSC | No. of the last of |
| FAX number | 801-864-4970 | |
| Number of p | ages:4 | b. |
| Reference: | ACOUSTIC HORNS | |

JEFF, I HAVE PUT TOGETHER A CONSERVATIVE APPROACH TO THE HORN TESTS. AFTER SPEAKING WITH OUR ENGINEERS, WE RECOMMEND THAT FIVE (5) HORNS BE USED. ONE TO BE USED INTERMITTENTLY.

EACH HORN SHALL BE PLUMBED WITH A SEPARATE CHECK VALVE TO PROVIDE MAXIMUM FLEXABILITY DURING HORN EVALUATIONS. A 1 1/2" CHECK VALVE WILL ALSO BE USED TO LOCK OUT ALL HORNS AT THE SAME TIME FOR SAFETY PURPOSES. WE WILL ALSO INCLUDE FIVE CHAIN HANGER ASSEMBLIES, FIVE STAINLESS STEEL FLEX HOSES AND ONE 1 1/2" FULL FLOW SOLENOID VALVE, AND OF COURSE THE (5) FIVE AH-25 HORNS.

MY PLAN IS TO PLACE ONE HORN CENTERED IN THE MIDDLE WALKWAY, AND ONE LOCATED IN THE OUTSIDE WALKWAYS NEAR EACH CORNER. SINCE EACH HORN WILL HAVE A DEDICATED CHECK VALVE. THIS WILL ALLOW US TO HAVE MORE FLEXABILITY IN EVALUATING THE NUMBER HORNS REQUIRED FOR THE MOST EFFICIENT CLEANING.

I HAVE PROVIDED TWO ADDITIONAL PAGES OF INFORMATION WHICH I WANT YOU TO REVIEW. A LIST OF ALL COMPONENTS NEEDED FOR THE TEST, AND THEIR MARKET LIST PRICE, AND A SUMMARY/CALCULATION OF OPERATIONAL COSTS OF A COMPLETE SYSTEM OF AH-25 HORNS. I THINK YOU SHOULD FIND THIS VERY INTERESTING.

I STILL REQUIRE A FULL SET OF DRAWINGS TO FORWARD TO OUR CAD ENGINEERING DEPARTMENT FOR INSTALLATION DRAWINGS. PLEASE FORWARD THEM AT YOUR EARLIEST CONVENIENCE SO THAT I CAN GET OUR FINAL RECOMMENDATIONS TO YOU.

WE WILL STILL NEED TO REVIEW TESTING PROCEDURES AND DATA EVALUATION. I WOULD LIKE TO SET UP A CONFERENCE CALL FOR THURSDAY OR FRIDAY TO REIVEW WITH OUR ACOUSTIC PRODUCTS MANAGER. PLEASE LET ME KNOW WHAT TIME WOULD BE GOOD FOR YOU.

816-356-8400 ext 375 Molecul FAX: 816-353-1873



DESCRIPTION OF ACOUSTIC HORN TESTING PROCEEDURES

PHASE I - ESTABLISH BASELINE DATA:

- 1. ESTABLISH REVERSE AIR FLOW IN THE COMPARTMENT
- 2. ESTABLISH INDIVIDUAL COMPARTMENT AND FLANGE TO FLANGE PRESSURE DROP
- 3. ESTABLISH INDIVIDUAL BAG WEIGHTS TO DETERMINE COMPARTMENT AVERAGE
- MONITOR ID, FD, AND REVERSE AIR FAN CURRENTS
- 5. MONITOR TYPICAL HOPPER ASH LEVELS

PHASE 2 - SONIC HORN STARTUP IN TEST COMPARTMENT:

- 1. INSTALL AND INSPECT AIR SUPPLY PLUMBING
- 2. TEST AIR PRESSURE TO HORNS
- 3. INSPECT INDIVIDUAL HORNS FOR PROPER OPERATION
- 4. COMPLETE SOUND MAPPING THROUGHOUT COMPARTMENT
- 5. PERFORM AMBIENT SOUND ANALYSIS

PHASE 3 - QUANITIFY PERFORMANCE OF HORNS AND REVIEW RESULTS

ALL OF THE DATA SHOWN IN PHASE I SHOULD BE REPEATED AFTER BOTH SOUNDINGS OF THE FOUR HORNS AND THE FIVE HORNS. INFORMATION SHALL THEN BE COLLECTED AND PREPARED FOR COMPARISON PURPOSES AND EXTRAPOLATED TO DETAIL EXPECTED FULL SYSTEM PERFORMANCE.

IPSC UNIT #2 ACOUSTIC HORN TEST MODULE COMPONENTS

| QUANITY | DISCRIPTION | UNIT PRICE |
|--|---|--|
| FIVE (5) FIVE (5) ONE (1) ONE (1) FIVE (5) | 3/4" MANUEL CHECK VALVE 3/4" STAINLESS STEEL FLEX HOSE 1 1/2" MANUEL ISOLATION VALVE 1 1/2" FULL FLOW SOLENOID VALVE CHAIN HANGER ASSEMBLY 9' CHAIN | \$58.00 \$96.00 \$96.00 \$274.00 \$85.00 |
| FIVE (5) | BHA AH-25 ACOUSTIC HORNS | \$1,785,00 |

BHA IS WILLING TO PROVIDE ALL OF THE ABOVE COMPONENTS FREE OF CHARGE FOR A PERIOD OF 120 DAYS FROM DATE OF SHIPMENT.



OPERATING EXPENSE WORKSHEET OF PROPOSED ACQUISTIC SYSTEM

FOR

INTERNOUNTAIN POWER SERVICE - DELTA, UTAH

Operating expense of an acoustic system is determined by three variables:

- . Air consumption
- Component parts replacement
- Relative maintenance labor

STANDARDS FOR COMPARISON

BHA - AH-25

Fundamental frequency output:

125 Hz

Level (dB) at 1 meter:

149 Hz

PWMF:

179 Hz

Air consumption specifications: 70 SCFM at

75 psig

Actual air consumption:

54 SCFM

Diaphragm plate:

Heat treated stainless steel

Material and construction:

A36 carbon steel

48 compartments

5 horns per comp.

CONE "ANTS

- Each horn will sound ten seconds per sounding.
- The horns will sound five times a day.
- The baghouse will operate 24 hours per day, 50 weeks per year.
- Kilowatt cost per hour is \$.025.
- 4 SCFM e brake horsepower (BHP).

- >
- Motor efficiency of 90%.
- 1 H.P. = .746 KW

OPERATING EXPENSE CALCULATIONS

BHA Acoustic System

Air Consumption (Rating)

54 SCFM/horn

Rating/Second

54 SCFM x <u>1 min.</u> 60 sec. = .90 SCF/sec./horn

Rating/Compartment

.90 SCF/sec./horn
x 5 horns/comp.
= 4.5 SCF/sec./comp.

Air Consumption (Per Compartment, Per Firing)

4.5 SCF/sec./comp.
x 10 sec./firing
= 45 SCF/firing/comp.

Air Consumption (Per Compartment, Per Day)

45 SCF/firing/comp. x 5 firing/day = 225 SCF/day/comp.

Air Consumption (Per System, Per Day)

225 SCF/dey/comp. x 48 comp. = 10,800 SCF/dey

Brake Horsepower, Per Day Required to Satisfy Air Consumption (1 BHP/4 SCF) 10,800 SCF/day x 1 BHP/4 SCF = 2,700 BHP/day

Power Rechired/Day (.746 KW/B' (.90-Motor Efriciency)

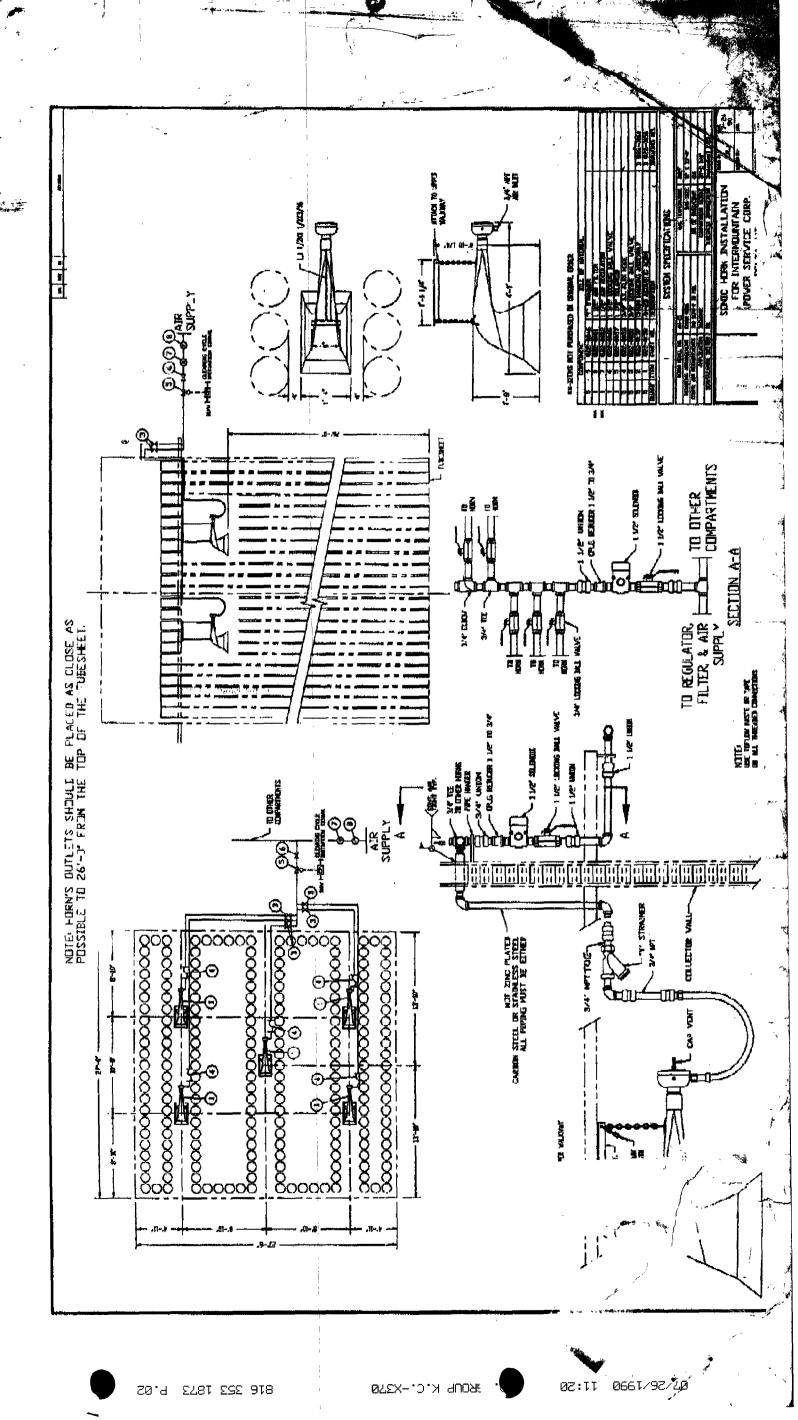
2,700 BHP/day x .746 KW/BHP ÷ .90 (M.E.) = 2,238 KW/day

(4)

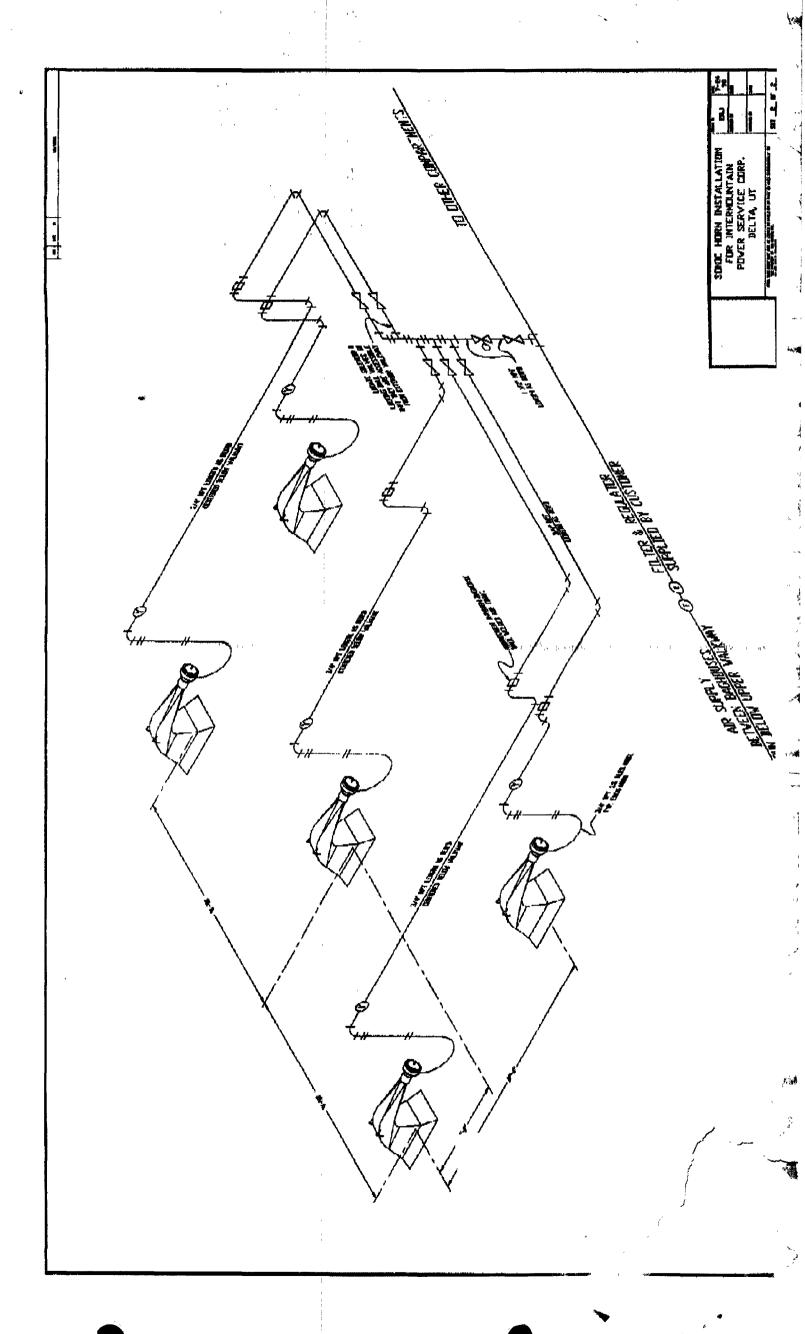
2,238 KW/day * .025/KW 95/day

> #57day ->> 1. vs/year 519,5mm 50. year

J. 30A



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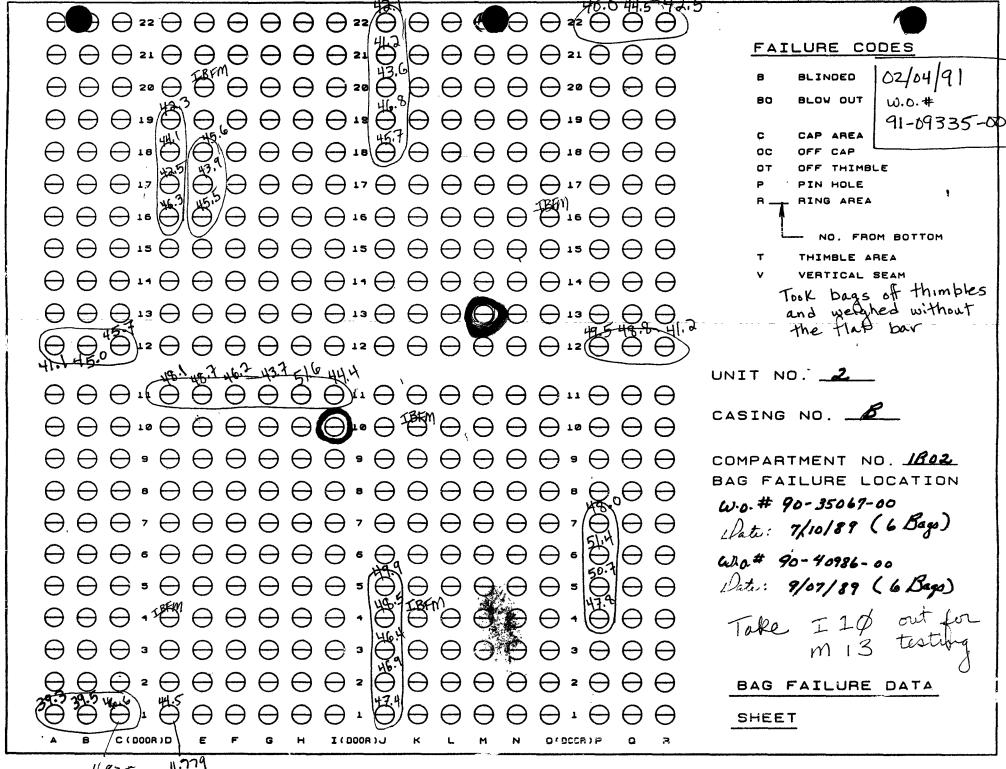
Appendix E

Bag Weight Surveys for Unit 2's Compartments B2 and B4

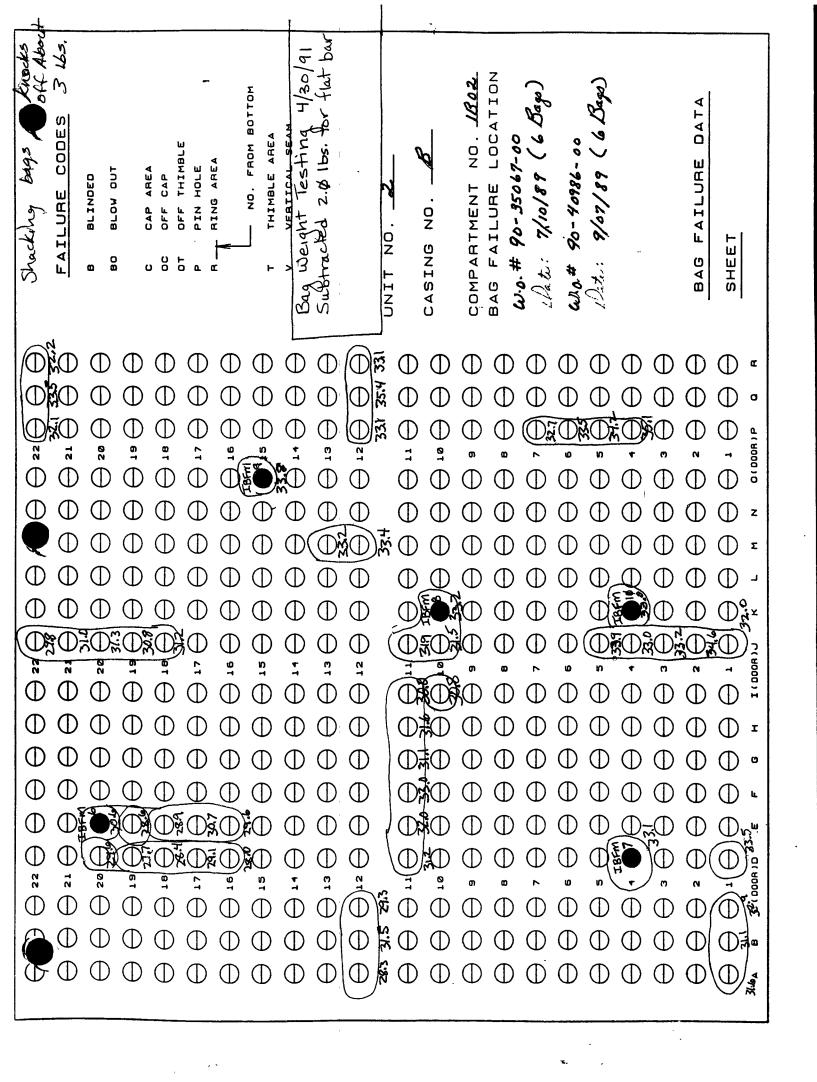
BAG WEIGHT SURVEYS FOR COMPARTMENT B2, UNIT 2

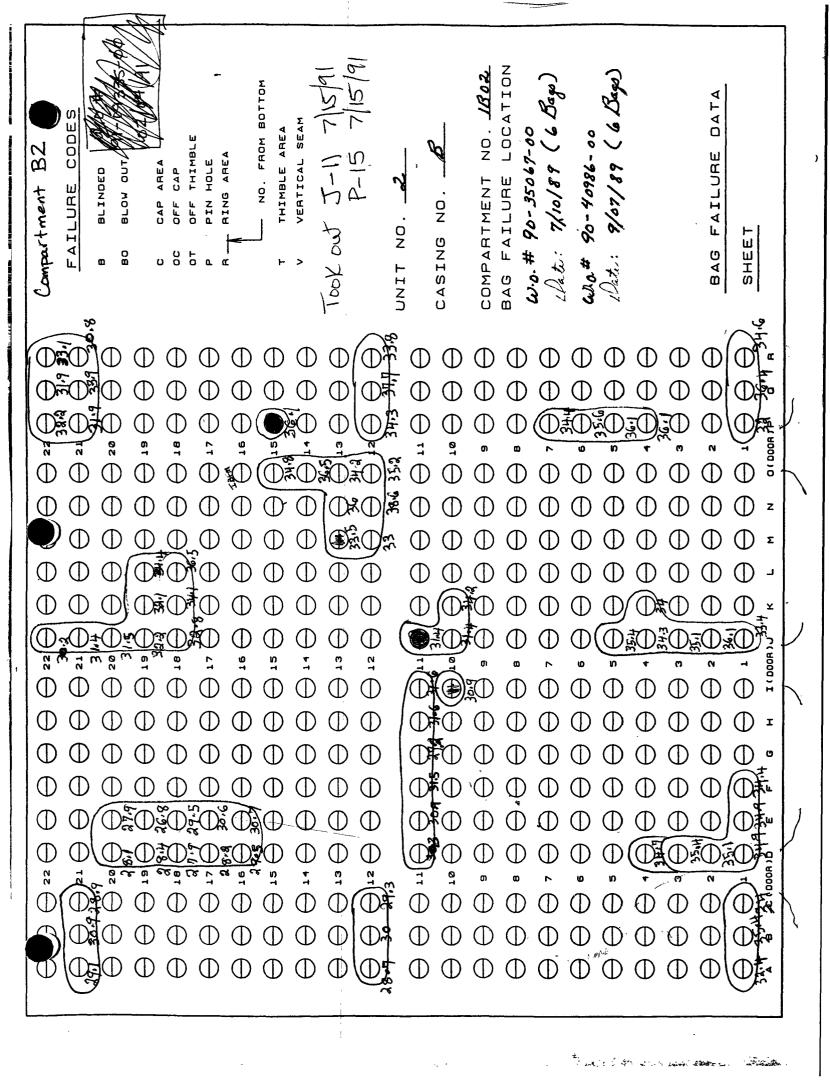
| Bag Weights are in pounds, Ibs. | | Before using Sonic Horns | ns | | |
|------------------------------------|--------------|-----------------------------|---------|---------|---------|
| - | Date | 2/4/91 | 4/30/91 | 7/15/91 | 9/24/91 |
| | Bag Location | | | | |
| 1 | A-1 | 39.3 | 31.6 | 32.4 | 30.7 |
| 2 | A-12 | 41.1 | 28.3 | 28.7 | 28.4 |
| 3 | A-21 | | | 29.1 | 30.0 |
| 4 | B-1 | 39.5 | 31.1 | 35.4 | 31.9 |
| 5 | B-12 | 45.0 | 31.5 | 30.0 | 29.9 |
| 6 | B-21 | | | 30.9 | 30.9 |
| 7 | C-1 | 46.6 | 32.9 | 34.0 | 31.6 |
| 8 | C-12 | 45.7 | 29.3 | 29.3 | 28.9 |
| 9 | C-21 | | | 28.9 | 28.0 |
| 10 | D-1 | 44.5 | 33.5 | 34.9 | 33.6 |
| 11 | D-2 | | | 35.1 | 34.8 |
| 12 | D-3 | | | 35.4 | 34.7 |
| 13 | D-4 | | 33.1 | 34.7 | 34.6 |
| 14 | D-11 | 48.1 | 31.2 | 30.3 | 30.1 |
| 15 | D-16 | 46.3 | 28.0 | 29.5 | 27.4 |
| 16 | D-17 | 42.5 | 29.1 | 28.2 | 27.8 |
| 17 | D-18 | 44.1 | 28.4 | 27.9 | 27.5 |
| 18 | D-19 | 42.3 | 27.7 | 28.4 | 27.0 |
| 19 | D-20 | | 29.6 | 28.1 | 27.4 |
| 20 | E-1 | | | 34.9 | 34.7 |
| 21 | E-11 | 48.7 | 32.0 | 30.9 | 31.3 |
| 22 | E-16 | 45.5 | 29.6 | 30.7 | 30.1 |
| 23 | E-17 | 43.9 | 30.7 | 30.6 | 29.1 |
| 24 | E-18 | 45.6 | 28.9 | 29.5 | 28.7 |
| 25 | E-19 | | 28.6 | 26.8 | 27.3 |
| 26 | E-20 | | 30.6 | 27.9 | 28.2 |
| 27 | F-1 | | | 34.4 | 34.8 |
| 28 | F-11 | 46.2 | 33.0 | 30.9 | 32.1 |
| 29 | G-11 | 43.7 | 31.1 | 27.2 | 28.8 |
| 30 | H-11 | 51.6 | 31.6 | 31.6 | 31.4 |
| 31 | I-10 | | 30.8 | 30.9 | 29.5 |
| 32 | I-11 | 44.4 | 30.0 | 31.6 | 29.5 |
| 33 | J-1 | 47.4 | 32.0 | 33.4 | 33.1 |
| 34 | J-2 | 46.9 | 34.6 | 36.1 | 35.7 |
| 35 | J-3 | 46.4 | 33.2 | 35.1 | 34.1 |
| 36 | J-4 | 48.5 | 33.0 | 34.3 | 34.7 |
| 37 | J-5 | 49.9 | 33.9 | 35.4 | 34.7 |
| 38 | J-10 | | 31.5 | 31.4 | 31.6 |
| 39 | J-11 | | 31.9 | 31.4 | 29.7 |
| 40 | J-18 | 45.7 | 31.2 | 32.8 | 32.9 |
| 41 | J-19 | 46.8 | 30.8 | 32.2 | 33.0 |
| 42 | J-20 | 43.6 | 31.3 | 31.5 | 32.2 |
| 43 | J-21 | 41.2 | 31.0 | 31.4 | 30.5 |
| 44 | J-22 | 42.1 | 29.8 | 30.2 | 29.8 |

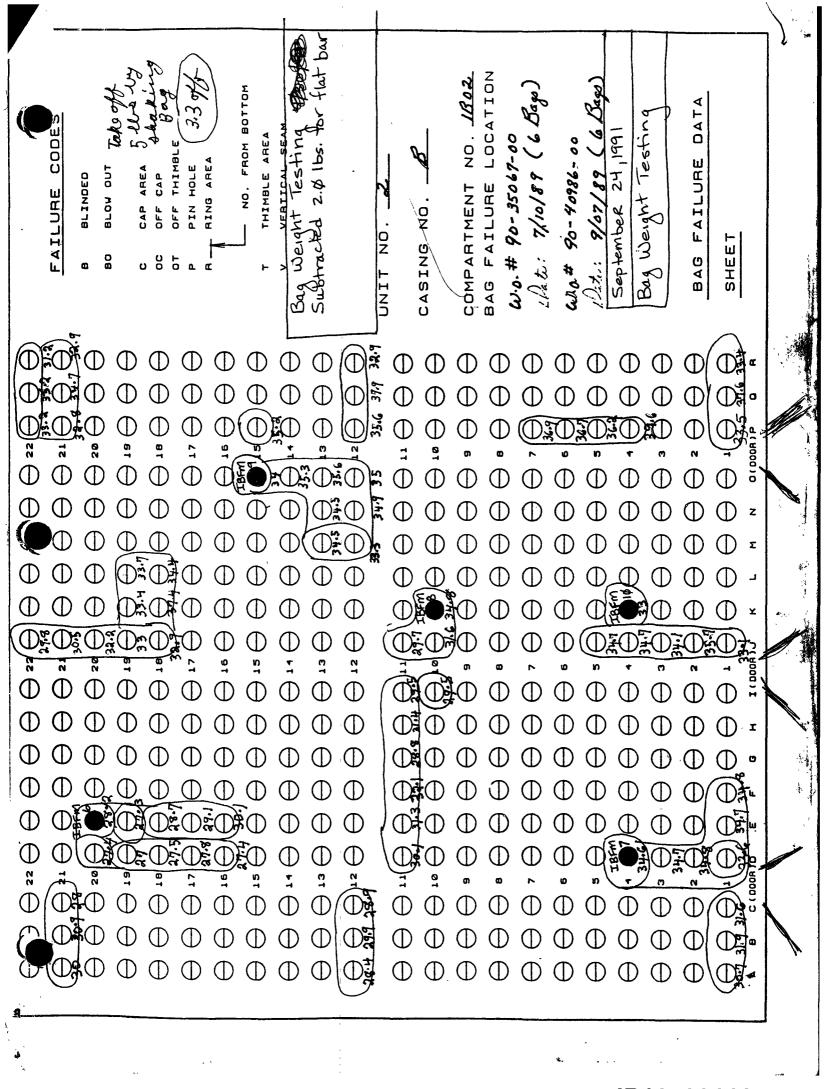
| Bag Weigl in pounds | | Before using Sonic Horns | _ | | |
|---------------------|-----------------|-----------------------------|---------|---------|---------|
| | Date | 2/4/91 | 4/30/91 | 7/15/91 | 9/24/91 |
| | Bag Location | - 2/4/31 | 4700701 | 7710701 | 0,21,01 |
| 45 | K-4 | <u> </u> | 33.8 | 34.0 | 33.0 |
| 46 | K-10 | | 33.2 | 34.2 | 34.8 |
| 47 | K-18 | | 1 00.2 | 34.1 | 37.4 |
| 48 | K-19 | | | 32.1 | 33.4 |
| 49 | L-18 | 1 | | 36.5 | 34.4 |
| 50 | L-19 | | | 34.4 | 33.7 |
| 51 | M-12 | | 33.4 | 33.0 | 33.3 |
| 52 | M-13 | | 33.2 | 33.5 | 34.5 |
| 53 | N-12 | | | 38.6 | 34.9 |
| 54 | N-13 | | | 36.0 | 34.5 |
| 55 | 0-12 | | | 35.2 | 35.0 |
| 56 | 0-13 | | | 34.2 | 35.6 |
| 57 | 0-14 | | | 36.5 | 35.3 |
| 58 | 0-15 | | 33.8 | 34.8 | 34.0 |
| 59 | P-1 | | | 32.0 | 33.5 |
| 60 | P-4 | 47.8 | 35.1 | 36.1 | 39.6 |
| 61 | P-5 | 50.7 | 34.2 | 36.1 | 36.2 |
| 62 | P-6 | 51.4 | 33.5 | 35.6 | 36.7 |
| 63 | P-7 | 48.0 | 32.7 | 34.4 | 36.9 |
| 64 | P-12 | 49.5 | 33.1 | 34.3 | 35.6 |
| 65 | P-15 | | | 36.4 | 35.2 |
| 66 | P-21 | | | 31.9 | 32.8 |
| 67 | P-22 | 40.0 | 32.1 | 32.2 | 33.2 |
| 68 | Q-1 | | | 36.4 | 37.6 |
| 69 | Q-12 | 48.8 | 35.4 | 37.7 | 37.9 |
| 70 | Q-21 | | | 33.9 | 34.7 |
| 71 | Q-22 | 44.5 | 33.5 | 31.9 | 35.2 |
| 72 | R-1 | | | 34.6 | 33.4 |
| 73 | R-12 | 41.2 | 33.1 | 33.8 | 32.9 |
| 74 | R-21 | | | 30.8 | 32.9 |
| 75 | R-22 | 42.5 | 32.2 | 33.1 | 31.2 |
| | | | | | |
| | Average Bag | | | | |
| | Weight, lbs. | 45.4 | 31.7 | 32.7 | 32.6 |
| | | | | | |
| | Standard | | | | |
| | Deviation, lbs. | 3.2 | 1.9 | 2.8 | 3.0 |
| | | | | | |
| | Number of | 40 | F0 | 75 | 76 |
| | Bags Weighed | 40 | 52 | 75 | 75 |



11.935 11.876

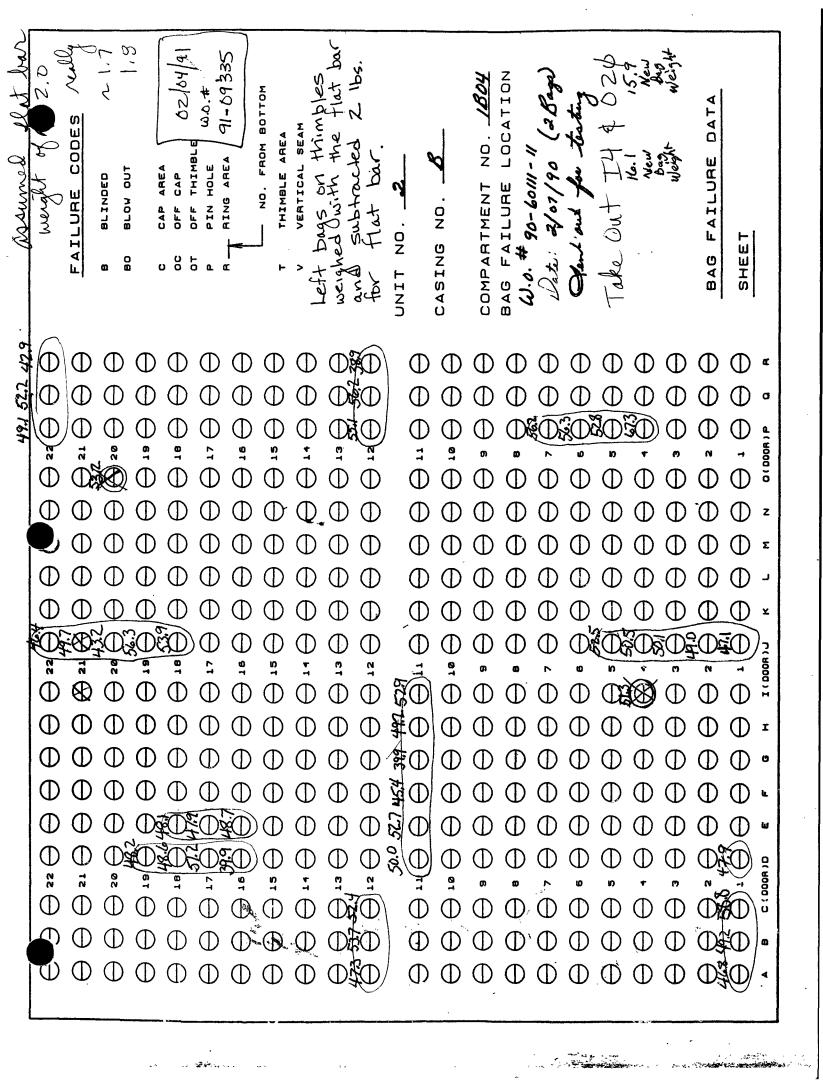


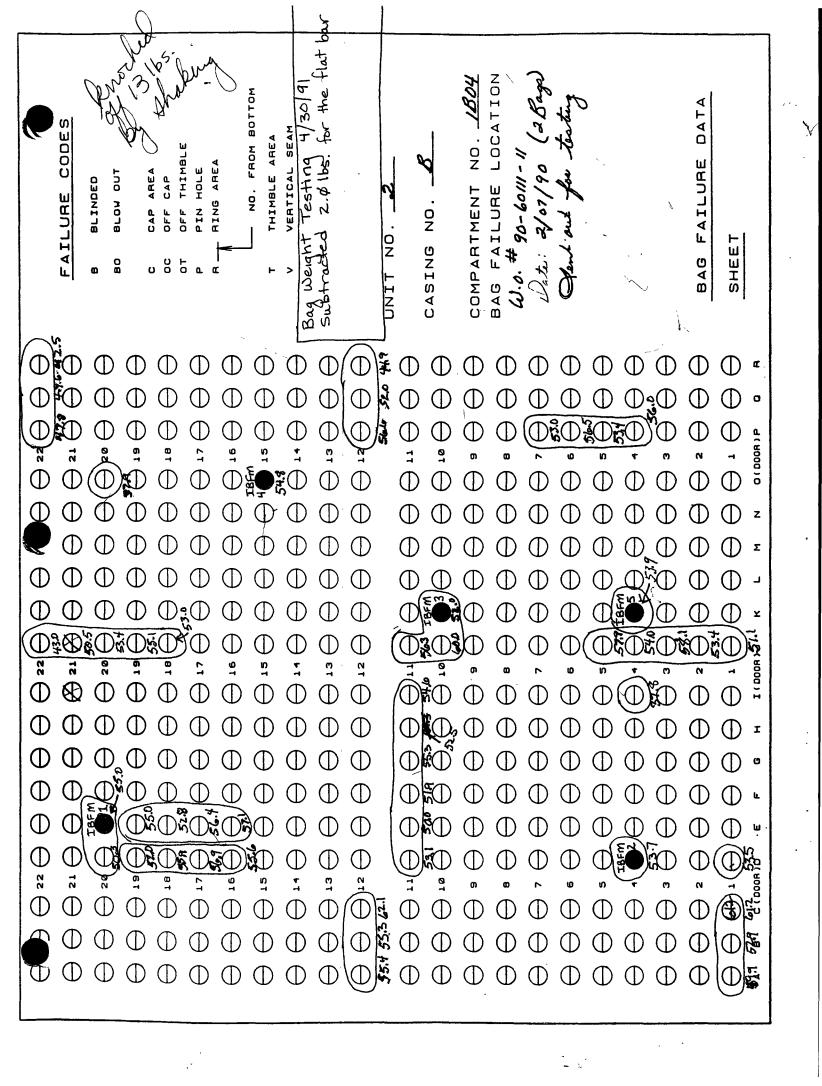


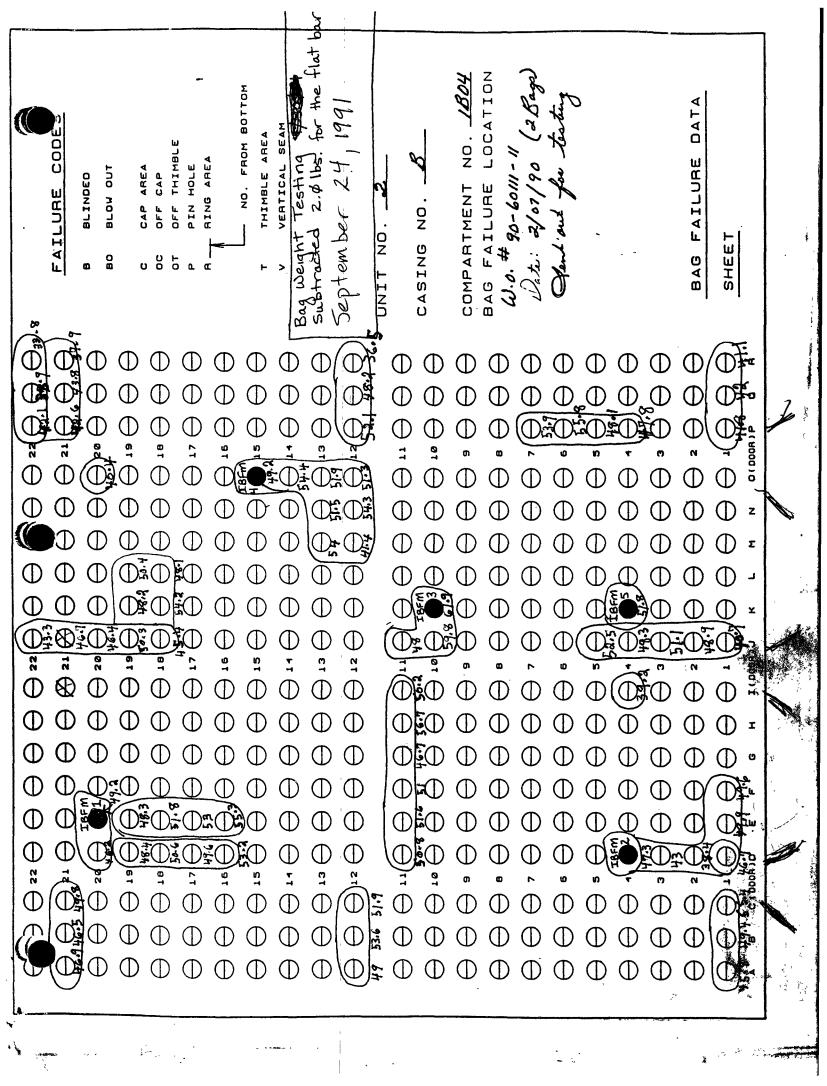


| Bag Weigh | | Before using | _ ^ | | |
|------------|----------------------|--------------|---------|---------|---------|
| in pounds, | | Sonic Horns | | | |
| | Date Bag Location | 2/4/91 | 4/30/91 | 7/15/91 | 9/24/91 |
| 1 | A-1 | 46.8 | 59.9 | | 45.8 |
| 2 | A-12 | 47.3 | 55.4 | | 49.0 |
| 3 | A-21 | | | | 46.9 |
| 4 | B-1 | 49.2 | 52.9 | | 49.4 |
| 5 | B-12 | 53.7 | 55.3 | | 53.6 |
| 6 | B-21 | | | | 46.5 |
| 7 | C-1 | 58.8 | 61.2 | | 55.4 |
| 8 | C-12 | 52.4 | 62.1 | | 51.9 |
| 9 | C-21 | | | | 49.8 |
| 10 | D-1 | 47.9 | 53.5 | | 46.7 |
| 11 | D-2 | | | | 38.4 |
| 12 | D-3 | | | | 43.0 |
| 13 | D-4 | | 53.7 | | 47.3 |
| 14 | D-11 | 50.0 | 53.1 | | 50.8 |
| 15 | D-16 | 39.9 | 55.6 | | 53.2 |
| 16 | D-17 | 51.2 | 56.9 | | 49.6 |
| 17 | D-18 | 48.6 | 55.9 | | 50.6 |
| 18 | D-19 | 48.2 | 52.0 | | 48.4 |
| 19 | D-20 | | 50.3 | | 46.2 |
| 20 | E-1 | | | | 49.9 |
| 21 | E-11 | 52.7 | 50.0 | | 51.6 |
| 22 | E-16 | 48.7 | 57.1 | | 55.3 |
| 23 | E-17 | 47.9 | 56.4 | | 53.0 |
| 24 | E-18 | 48.1 | 52.8 | | 51.8 |
| 25 | E-19 | | 55.0 | | 48.3 |
| 26 | E-20 | | 55.0 | | 49.2 |
| 27 | F-1 | | | | 49.6 |
| 28 | F-11 | 45.4 | 51.9 | | 51.0 |
| 29 | G-11 | 39.9 | 55.3 | | 46.7 |
| 30 | H-11 | 49.7 | 52.5 | | 56.7 |
| 31 | 1-4 | 51.3 | 37.8 | | 39.2 |
| 32 | 1-11 | 52.9 | 54.6 | | 50.2 |
| 33 | J-1 | 47.1 | 51.1 | | 40.7 |
| 34 | J-2 | 49.0 | 53.4 | | 48.9 |
| 35 | J-3 | 50.1 | 58.1 | | 51.1 |
| 36 | J-4 | 50.5 | 54.0 | | 48.3 |
| 37 | J-5 | 52.5 | 57.9 | | 52.5 |
| 38 | J-10 | | 60.0 | | 59.8 |
| 39 | J-11 | | 56.3 | | 48.0 |
| 40 | J-18 | 53.9 | 53.0 | | 45.4 |
| 41 | J-19 | 56.3 | 55.1 | | 50.3 |
| 42 | J-20 | 43.2 | 53.4 | | 46.4 |
| 43 | J-21 | 49.7 | 50.5 | | 46.7 |
| 44 | J-22 | 46.4 | 43.0 | L | 43.3 |

| Bag Weights are n pounds, Ibs. | | Before using Sonic Horns | | | |
|-----------------------------------|---------------------------|-----------------------------|--|---------|---------|
| ii podiida, | Date | 2/4/91 | 4/30/91 | 7/15/91 | 9/24/91 |
| | Bag Location | - 2/4/31 | 4/30/31 | 7713731 | 0/2-1/0 |
| 45 | K-4 | | 53.9 | | 51.8 |
| 46 | K-10 | | 52.0 | | 61.9 |
| | K-18 | | 32.0 | | 54.2 |
| 48 | K-19 | | | | 48.2 |
| 49 | L-18 | | | | 48.1 |
| 50 | L-19 | | | | 50.4 |
| 51 | M-12 | | | | 41.4 |
| 52 | M-13 | | | | 54.0 |
| 53 | N-12 | | - | | 54.3 |
| 54 | N-13 | | | | 51.5 |
| <u>55</u> | 0-12 | | | | 51.3 |
| 56 | 0-13 | + | | | 51.9 |
| 57 | 0-14 | | | | 54.4 |
| 58 | 0-15 | | 54.8 | | 49.2 |
| <u>58</u> | 0-20 | 53.2 | 37.9 | | 40.4 |
| 60 | P-1 | 33.2 | 37.3 | | 41.8 |
| 61 | P-4 | 67.3 | 56.0 | | 47.8 |
| 62 | P-5 | 52.8 | 53.4 | | 48.1 |
| 63 | P-6 | 56.3 | 56.5 | | 55.8 |
| 64 | P-7 | 56.2 | 53.0 | | 53.9 |
| 65 | P-12 | 55.1 | 56.6 | | 52.1 |
| 66 | P-21 | 55.1 | 30.0 | | 42.6 |
| 67 | P-22 | 49.1 | 47.8 | | 42.1 |
| 68 | Q-1 | 43.1 | 47.0 | · | 42.0 |
| 69 | Q-12 | 56.2 | 52.0 | | 48.2 |
| 70 | Q-21 | 30.2 | 32.0 | | 43.8 |
| 71 | Q-22 | 52.2 | 49.6 | | 38.9 |
| 72 | R-1 | 32.2 | 43.0 | | 41.1 |
| 73 | R-12 | 38.9 | 44.9 | | 36.5 |
| 73 74 | R-12 | 30.8 | 44.3 | | 37.8 |
| <u>74</u> 75 | R-22 | 42.9 | 42.5 | | 33.8 |
| 73 | 11-22 | 142.3 | 42.0 | | 33.0 |
| | Average Bag | | | | i |
| | Weight, lbs. | 50.2 | 53.2 | , | 48.3 |
| | | | | | |
| | Standard | | | | · |
| | Deviation, lbs. | 5.3 | 5.0 | | 5.4 |
| | I.: | | | | |
| | Number of Bags Weighed | 42 | 51 | | 75 |







Appendix F

Sound Pressure Level Testing in Unit 2's Compartment B2

BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL) DATA SHEET

Unit 2 Baghouse Casing B Compartment B2

9/28/91 11:00 All Doors Shut Three Horn Operation: Two Horns in South Aisle and Horn near Door in North Aisle

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | | |
| 2 | 33 | 138.0 | 158.9 |
| 3 | 32 | 138.7 | 172.2 |
| 4 | 31 | 135.0 | 112.5 |
| 5 | 30 | 134.6 | 107.4 |
| 6 | 29 | 136.5 | 133.7 |
| 7 | 28 | 140.2 | 204.7 |
| 8 | 27 | 139.8 | 195.4 |
| 9 | 26 | 138.0 | 158.9 |
| 10 | 25 | 131.6 | 76.0 |
| 11 | 24 | 130.5 | 67.0 |
| 12 | 23 | 135.0 | 112.5 |
| 13 | 22 | 135.0 | 112.5 |
| 14 | 21 | 133.1 | 90.4 |
| 15 | 20 | 135.7 | 121.9 |
| 16 | 19 | 137.6 | 151.7 |
| 17 | 18 | 136.8 | 138.4 |
| 18 | 17 | 133.5 | 94.6 |
| 19 | 16 | 134.2 | 102.6 |
| 20 | 15 | 136.8 | 138.4 |
| 21 | 14 | 136.5 | 133.7 |
| 22 | 13 | 133.8 | 98.0 |
| 23 | 12 | 134.6 | 107.4 |
| 24 | 11 | 136.1 | 127.7 |
| 25 | 10 | 136.8 | 138.4 |
| 26 | 9 | 135.0 | 112.5 |
| 27 | 8 | 134.2 | 102.6 |
| 28 | 7 | 132.7 | 86.3 |
| 29 | 6 | 135.7 | 121.9 |
| 30 | 5 | 136.5 | 133.7 |
| 31 | 4 | 137.6 | 151.7 |
| 32 | 3 | 132.7 | 86.3 |
| 33 | 2 | 128.6 | 53.8 |
| 34 | 1 | 137.6 | 151.7 |
| 35 | 0 | 141.0 | 224.4 |

| Average Integrated | 136.0 | 125.9 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

with how all the sir purge of how all the sir

Table 3-1

DATA FORM BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL) unit Z

Compartment: Measurement Position: Number: 3 25 PWMF. Horn Type Hz Height Above Tubesheet, ft SPL at PWMF, dB* Integrated Sound Pressure, Pa Sound Pressure Integrated SPL, dB* at PWMF, Pa 2 Ft 33 5ft 3**8.**0 32 31 134.6 30 29 28 27 26 24 23 22 21 20 19 16 18 17 16 15 20 14 133.8 13 134.6 12 136. 11

10

136.B

Note This form may be reproduced * To convert to sound pressure $\rho = \rho_0 \log^{-1}(L_p/20)$

| Circurent of Resourcest of Depterson | É | BAGHOUS | SE COMPAR | Table 3-1 DATA FORM TMENT SOUND F | PRESSURE LEV | (EL (SPL) |
|--|--------------------|-----------------|---|---|----------------------|-------------------------------|
| 1250 | Date 9 | 28/91 | Compartment | B-Z | Measurement Position | n:A |
| PAIN | Horn Type | · | <u>,</u> | Number P | WMF: | Hz |
| 00 | Height / Tubesh | Above | Integrated SPL, dB* | Integrated Sound Pressure, Pa | SPL at PWMF, dB* | Sound Pressure at PWMF, Pa |
| with all | 26 | 9 | 135.0 | | | |
| Joseph | 27 | 8 | 134.2 | | | |
| with all soors shult air purge air | 28 | 7 | 132.7 | | | |
| a ar | (29) | 6 | 135.7 | | | |
| pure 11 | 30 | 5 | 136.5 | | | |
| fan of | _31 | 4 | 137.6 | | | |
| | 32_ | 3 | 135.0 | (132.7) | | |
| | (33) | 2 | 128.6 | (129.7) | | |
| | 34 | 1 | 137.6 | | | |
| (| (35) | 0 | 141.0 | | 1 | |
| (| | | | | | |
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| | <u></u> | | | | | |
| | | חלמ | | | + | |
| THIS | 32 | 47 | 122 (| | | |
| LOCATION | 33 | 3 | 133.5 | | + | |
| D. Jour | | 2 | 134.2 | | + | |
| NO FAN | _ \ | 0 | | | | / |
| • | (| U | 136.1 | | | |
| OPEN | 32 | 3 | 131.2 | 131.6 | | |
| | E 22 | 2 | 133.5 | 135.0 | | |
| 0001 / FAI | 24 | 1 | 138.3 | 139,1 | | |
| 7000 | Note This form m | nay be reproduc | $ced \frac{3G}{b} = b_0 \log H(L_p 20)$ | 140.6 | | |
| | (3) | and proposite £ | Projuge (Lp/20) | - | | |
| Door | | | | | | |
| \ | | | | | | |

BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL) DATA SHEET

| Unit 2 Baghouse Casing B | | Compartment B2 | ··· |
|-----------------------------|--------------------------------|-----------------------|--|
| 9/28/91 16:00 Location A | Doors Open Purge Air Fan On | Three Horn Operation: | Two Horns in South Aisle and Horn near Door in North Aisle |

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 11 | 34 | 134.2 | 102.6 |
| 2 | 33 | 134.2 | 102.6 |
| 3 | 32 | 131.6 | 76.0 |
| 4 | 31 | 131.6 | 76.0 |
| 5 | 30 | 134.6 | 107.4 |
| 6 | 29 | 136.1 | 127.7 |
| 77 | 28 | 137.6 | 151.7 |
| 8 | 27 | 136.8 | 138.4 |
| 9 | 26 | 133.8 | 98.0 |
| 10 | 25 | 134.6 | 107.4 |
| 11 | 24 | 134.6 | 107.4 |
| 12 | 23 | 132.3 | 82.4 |
| 13 | 22 | 133.5 | 94.6 |
| 14 | 21 | 137.6 | 151.7 |
| 15 | 20 | 141.0 | 224.4 |
| 16 | 19 | 141.3 | 232.3 |
| 17 | 18 | 137.2 | 144.9 |
| 18 | 17 | 135.0 | 112.5 |
| 19 | 16 | 136.5 | 133.7 |
| 20 | 15 | 139.1 | 180.3 |
| 21 | 14 | 139.1 | 180.3 |
| 22 | 13 | 140.2 | 204.7 |
| 23 | 12 | 141.0 | 224.4 |
| 24 | 11 | 139.8 | 195.4 |
| 25 | 10 | 137.2 | 144.9 |
| 26 | 9 | 139.8 | 195.4 |
| 27 | 8 | 139.5 | 188.8 |
| 28 | 7 | 136.8 | 138.4 |
| 29 | 6 | 136.8 | 138.4 |
| 30 | 5 | 138.7 | 172.2 |
| 31 | 4 | 138.7 | 172.2 |
| 32 | 3 | 134.2 | 102.6 |
| 33 | 2 | 133.5 | 94.6 |
| 34 | 1 | 139.5 | 188.8 |
| 35 | 0 | 143.2 | 289.1 |

| Average Integrated | 137.4 | 148.1 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

Table 3-1

DATA FORM BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL)

| 0 00 | Date. Sat | 9/28/0 | Compartment: | B-2 | Measurement Position | n: <u>A</u> |
|--|--------------------|------------------|------------------------|----------------------------------|----------------------|-------------------------------|
| All doors open air | Horn Type | | | Number P | WMF | Hz |
| new 4: | Height / Tubesh | Above eet, ft | Integrated SPL, dB* | Integrated Sound Pressure, Pa | SPL at PWMF, dB* | Sound Pressure at PWMF, Pa |
| of at | OFF CAP | 34 | 134.2 | | | |
| pury on | 2 ^{ft} | 33 | 134.2 | | | |
| 1 1 | 2 ft | 32 | 131.6 | | | |
| All | (4) | 31 | 131.6 | | | |
| 2 hours 2 hours wisle middle | 5 | 30 | 134.6 | | | |
| 2 M. O. St | 6 | 29 | 136.1 | | | |
| | 7 | 28 | 137.6 | | | |
| aiste | (8) | 27 | 136.8 | | | |
| , , ~ | 9 | 26 | 133.8 | | | |
| homoe | 10 | 25 | 134.6 | | | |
| aniel | 11 | 24 | 134.6 | | | |
| - oth | 12 | 23 | 132.3 | | | |
| | 13 | 22 | 133.5 | | | |
| bux | 14 | 21 | 137.6 | | | |
| how " One is | کیار | 20 | 141.0 | | | |
| how by on and front in right (port in selection) | (16) | 19 | 141.3 | | | |
| in rustice | 11 | 18 | 137.2 | | | |
| islel | 18 | 17 | 135.0 | | | |
| D. ou | 19 | 16 | 1365 | | | |
| NOW W | 20 | 15 | 139.1 | | | |
| M | 21 | 14 | 139.1 | | | |
| 7)() | 22 | 13 | 140.2 | | | |
| V | 23 | 12 | 141.0 | | | |
| | 24 | | 139.8 | | | |
| | | | | | | |

Note This form may be reproduced *To convert to sound pressure $p = p_0 \log^{-1}(L_p/20)$

DATA FORM BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL)

will open who open to have one

| Date _Sa | t 9/28/9 | 7/ Compartment. | B-2 | Measurement Position | A |
|--------------------------|------------------------|------------------------|----------------------------------|--|-------------------------------|
| | | | Number PV | | Hz |
| Heig Tube | ht Above esheet, ft | Integrated SPL, dB* | Integrated Sound Pressure, Pa | SPL at PWMF, dB* | Sound Pressure at PWMF, Pa |
| 25 | 10 | 137.2 | | | |
| 26 | 9 | 139.8 | | | |
| 27 | 88 | 139.5 | | | |
| (28) | 7 | 136.8 | | | |
| 29 | 6_ | 136.8 | | | |
| 30 | 5 | 138.7 | | | |
| 31 | 4 | 138.7 | | | |
| (32) | 3 | 136.8 | (134.2) | | |
| <u>33</u> | 2 | 133.5 | | | |
| <u>34</u> <u>35</u>) | <u> </u> | 139.5 | | | |
| (35) | 0 | 143.2 | | | |
| | | | | | |
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Note This form may be reproduced *To convert to sound pressure $p = p_0 \log^{-1}(L_p/20)$

Unit 2 Baghouse Casing B Compartment B2

9/28/91 18:47 Doors Open Three Horn Operation: Two Horns in South Aisle and Horn near Door in North Aisle

| Height Above | Integrated Sound | Integrated Sound |
|---------------------------------------|---|--|
| | | Pressure, Pa |
| | | 164.4 |
| | | 158.9 |
| · · · · · · · · · · · · · · · · · · · | | 195.4 |
| | | 172.2 |
| | | 232.3 |
| | 144.0 | 317.0 |
| | 143.6 | 302.7 |
| 27 | 141.7 | 243.2 |
| 26 | 140.2 | 204.7 |
| 25 | 145.5 | 376.7 |
| 24 | 147.7 | 485.3 |
| 23 | 146.6 | 427.6 |
| 22 | 142.5 | 266.7 |
| 21 | 144.0 | 317.0 |
| 20 | 144.3 | 328.1 |
| 19 | 144.0 | 317.0 |
| 18 | 140.6 | 214.3 |
| 17 | 139.1 | 180.3 |
| 16 | 140.6 | 214.3 |
| 15 | 140.2 | 204.7 |
| 14 | 140.6 | 214.3 |
| 13 | 140.6 | 214.3 |
| 12 | <u> </u> | 138.4 |
| 11 | | 133.7 |
| | | 195.4 |
| · · · · · · · · · · · · · · · · · · · | | 232.3 |
| | | 188.8 |
| | 4 | 138.4 |
| | 4 | 195.4 |
| | 4 | 328.1 |
| | · | 317.0 |
| | | 164.4 |
| <u> </u> | | 144.9 |
| | · · · · · · · · · · · · · · · · · · · | 317.0 |
| | | 408.3 |
| | Tubesheet, feet 34 33 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 | Tubesheet, feet Pressure Level, dB 34 138.3 33 138.0 32 139.8 31 138.7 30 141.3 29 144.0 28 143.6 27 141.7 26 140.2 25 145.5 24 147.7 23 146.6 22 142.5 21 144.0 20 144.3 19 144.0 18 140.6 17 139.1 16 140.6 15 140.2 14 140.6 13 140.6 13 140.6 13 140.6 13 140.6 13 140.6 13 140.6 13 140.6 13 140.6 13 140.6 13 140.6 13 |

| Average Integrated | 141.8 | 247.2 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

DATA FORM BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL)

| | .~\ | ev |
|---------|-----|----------|
| Deer | 90 | for |
| Desco | ar | |
| and the | • | <i>,</i> |
| hun | سسر | |
| M | | () |

| Date 9/2 | 8/91 | Compartment _ | B-2_ | Measurement Position | . <u>B</u> |
|----------------|-----------------------|------------------------|----------------------------------|----------------------|-------------------------------|
| Horn Type _ | | | Number PV | | |
| Heigh Tubes | nt Above sheet, ft | Integrated SPL, dB* | Integrated Sound Pressure, Pa | SPL at PWMF, dB* | Sound Pressure at PWMF, Pa |
| 1 | 3낙 | 138.3 | | | |
| 2 | 33 | 138.0 | | | |
| 3 | 32 | 139.8 | | | |
| <u>4</u>) | 31 | 138.7 | | | |
| 5 | 30 | 141.3 | | | <u> </u> |
| 6 | 29 | 144.0 | | | |
| 7 | | 143.6 | | | |
| <u> </u> | 27 | 141.7 | | | |
| 9 | 26 | 140.2 | | | |
| 10 | 25 | 145.5 | | | |
| П | 24 | 147.7 | | | |
| 12) | 23 | 146.6 | ··· | | |
| 13 | 22 | 142.5 | | | |
| 14 | 21 | 144.0 | · | | |
| 15_ | 20 | 144.3 | | | |
| (b) | 19 | 144.0 | | | |
| 17 | 18 | 140.6 | | | |
| 18 | 17 | 139.1 | | | |
| 9 | 16 | 140.6 | | | |
| 20 | 15 | 140.2 | | | |
| 21 | 14 | 140.6 | ·· | | |
| 22 | 13 | 140.6 | | | |
| 23 | 12 | 136.8 | | | |
| 24) | - 11 | 136.5 | | | |

Note This form may be reproduced *To convert to sound pressure $p = p_0 \log^{-1}(L_p/20)$

Table 3-1 **DATA FORM** BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL)

Dons open purge sir for surry

| Date 9/28/91 | Compartment | B-2 | Measurement Position | B |
|-------------------------------|------------------------|----------------------------------|----------------------|-------------------------------|
| | | Number: P | | Hz |
| Height Above Tubesheet, ft | Integrated SPL, dB* | Integrated Sound Pressure, Pa | SPL at PWMF, dB* | Sound Pressure at PWMF, Pa |
| 25 10 | 139.8 | | | |
| 26 9 | 141.3 | | | |
| 27 8 | 139.5 | | | |
| 28) 7 | 136.8 | | | |
| 29 6 | 139.8 | | | |
| 30 5 | 144.3 | | | <u> </u> |
| 31 4 | 144.0 | | | |
| (32) 3 | 141.0 | (138.3) | | |
| 33 2 | 137.2 | | | |
| 34 1 | 144.0 | | | |
| (35) 0 | 146.2 | | | |
| | | | | |
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Note This form may be reproduced *To convert to sound pressure: $p = p_0 \log^{-1}(L_p/20)$

| Unit 2 Baghouse | Casing B | Compartment B2 | |
|-----------------------------|--------------------------------|-----------------------|--|
| 9/29/91 15:08 Location C | Doors Open Purge Air Fan On | Three Horn Operation: | Two Horns in South Aisle and Horn near Door in North Aisle |

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 139.5 | 188.8 |
| 2 | 33 | 140.2 | 204.7 |
| 3 | 32 | 134.2 | 102.6 |
| 4 | 31 | 136.5 | 133.7 |
| 5 | 30 | 136.1 | 127.7 |
| 6 | 29 | 139.1 | 180.3 |
| 7 | 28 | 136.1 | 127.7 |
| 8 | 27 | 139.5 | 188.8 |
| 9 | 26 | 138.7 | 172.2 |
| 10 | 25 | 140.6 | 214.3 |
| 11 | 24 | 143.2 | 289.1 |
| 12 | 23 | 143.2 | 289.1 |
| 13 | 22 | 139.1 | 180.3 |
| 14 | 21 | 138.7 | 172.2 |
| 15 | 20 | 140.6 | 214.3 |
| 16 | 19 | 141.3 | 232.3 |
| 17 | 18 | 139.1 | 180.3 |
| 18 | 17 | 139.1 | 180.3 |
| 19 | 16 | 138.3 | 164.4 |
| 20 | 15 | 141.0 | 224.4 |
| 21 | 14 | 141.0 | 224.4 |
| 22 | 13 | 142.1 | 254.7 |
| 23 | 12 | 140.2 | 204.7 |
| 24 | 11 | 138.0 | 158.9 |
| 25 | 10 | 139.5 | 188.8 |
| 26 | 9 | 142.5 | 266.7 |
| 27 | 8 | 142.1 | 254.7 |
| 28 | 7 | 137.6 | 151.7 |
| 29 | 6 | 137.2 | 144.9 |
| 30 | 5 | 144.3 | 328.1 |
| 31 | 4 | 145.1 | 359.8 |
| 32 | 3 | 137.2 | 144.9 |
| 33 | 2 | 130.5 | 67.0 |
| 34 | 1 | 139.5 | 188.8 |
| 35 | 0 | 141.7 | 243.2 |

| Average Integrated | 139.9 | 198.5 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

DATA FORM BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL)

Dons open Purg on fun

| Date | 7/29/94 | Compartment | B-2 | Measurement Position | n: |
|-----------------|-----------------------------|------------------------|----------------------------------|----------------------|-------------------------------|
| Horn Typ | e | | Number P\ | | |
| Н | eight Above ubesheet, ft | Integrated SPL, dB* | Integrated Sound Pressure, Pa | SPL at PWMF, dB* | Sound Pressure at PWMF, Pa |
| 1 | 34 | 139.5 | | | |
| 2 | 33 | 140.2 | | | |
| 3 | 37_ | 134.2 | | | |
| (4) | 31 | 1365 | | | |
| <u>4</u>) | 30 | 136.1 | | | |
| | 29 | 139.1 | | | |
| <u>6</u> 7 8 | 28 | 136.1 | | | |
| <u>(3)</u> | 27 | 139.5 | | | |
| 9 | 26 | 138.7 | | | |
| 10 | 25 | 140.6 | | | |
| 11 | 24 | 143.2 | | | |
| (12) | 23 | 143.2 | | | |
| 13 | 22 | 139.1 | | | |
| 14 | 21 | 138.7 | | | |
| 15 | 20 | 140.6 | | | |
| 16 | 19 | 141.3 | | | |
| 17 | 18 | 139.1 | | | |
| 18 | 17 | 139.1 | | | |
| 19 | 16 | 138.3 | | | |
| 20 | 15 | 141.0 | | | |
| 21_ | 14 | 141.0 | | | |
| 22 | 13 | 142.1 | | | |
| 23 | 12_ | 140.2 | | | |
| 24) | [1 | 138.D | | | |
| | | | | | |

Note This form may be reproduced *To convert to sound pressure $p = p_0 \log^{-1}(L_p/20)$

Table 3-1 **DATA FORM** BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL)

| Date | 7/29/91 | Compartment: | B-2 | _ Measurement Position | on |
|-----------|----------------------------|------------------------|----------------------------------|------------------------|-------------------------------|
| Horn Type | | | Number F | PWMF | Hz |
| He Tu | eight Above besheet, ft | Integrated SPL, dB* | Integrated Sound Pressure, Pa | SPL at PWMF, dB* | Sound Pressure at PWMF, Pa |
| 25 | 10 | 139.5 | | | |
| 26 | | 142.5 | | | |
| 72 | 88 | 142.1 | | | |
| 28 | 7 | 137.6 | | | |
| 29 | 6 | 137.2 | | | |
| 30 | 5_ | 144.3 | | | |
| 31 | 4 | 145.1 | | | |
| 32 | 3_ | 141.7 | (137.2) | | |
| 33 | | 130.5 | | | |
| 34 | | 139.5 | | | |
| 35 | 0 | 141.7 | | | |
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Note This form may be reproduced *To convert to sound pressure $p = p_0 \log^{-1}(L_p/20)$

| Unit 2 Baghouse | Casing B | Compartment B2 | _ |
|-----------------------------|--------------------------------|-----------------------|--|
| 9/29/91 16:04 Location D | Doors Open Purge Air Fan On | Three Horn Operation: | Two Horns in South Aisle and Horn near Door in North Aisle |

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 135.7 | 121.9 |
| 2 | 33 | 139.1 | 180.3 |
| 3 | 32 | 136.8 | 138.4 |
| 4 | 31 | 129.0 | 56.4 |
| 5 | 30 | 137.6 | 151.7 |
| 6 | 29 | 143.2 | 289.1 |
| 7 | 28 | 144.3 | 328.1 |
| 8 | 27 | 141.7 | 243.2 |
| 9 | 26 | 134.2 | 102.6 |
| 10 | 25 | 135.3 | 116.4 |
| 11 | 24 | 141.3 | 232.3 |
| 12 | 23 | 141.7 | 243.2 |
| 13 | 22 | 135.3 | 116.4 |
| 14 | 21 . | 131.2 | 72.6 |
| 15 | 20 | 140.2 | 204.7 |
| 16 | 19 | 142.8 | 276.1 |
| 17 | 18 | 140.6 | 214.3 |
| 18 | 17 | 139.1 | 180.3 |
| 19 | 16 | 130.8 | 69.3 |
| 20 | 15 | 136.5 | 133.7 |
| 21 | 14 | 139.5 | 188.8 |
| 22 | 13 | 141.3 | 232.3 |
| 23 | 12 | 138.3 | 164.4 |
| 24 | 11 | 132.3 | 82.4 |
| 25 | 10 | 135.0 | 112.5 |
| 26 | 9 | 138.7 | 172.2 |
| 27 | 8 | 138.7 | 172.2 |
| 28 | 7 | 134.6 | 107.4 |
| 29 | 6 | 131.2 | 72.6 |
| 30 | 5 | 137.2 | 144.9 |
| 31 | 4 | 139.8 | 195.4 |
| 32 | 3 | 138.3 | 164.4 |
| 33 | 2 | 135.3 | 116.4 |
| 34 | 1 | 139.5 | 188.8 |
| 35 | 0 | 141.7 | 243.2 |

| Average Integrated | 138.4 | 166.5 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |
| | | |

House on funge on 4:04 p.M

DATA FORM BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL)

Compartment: Horn Type . Number _ Sound Pressure at PWMF, Pa SPL at PWMF, dB* Integrated Sound Pressure, Pa Height Above Tubesheet, ft Integrated SPL, dB* 135.7 34 33 139.1 136.8 32 129.0 31 137.6 30 143.2 29 28 29 141.7 26 134.2 35.3 25 10 24 23 22 131.2 21 140.2 20 19 140.6 18 17 18 17 130.8 136.5 15

13

12 11

139.5

138.3

132.3

Note This form may be reproduced *To convert to sound pressure $\rho = \rho_0 \log^{-1}(L_p/20)$

DATA FORM BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL)

| Sun. Date. 9/29/91 | Compartment | B-2 | Measurement Position | n: |
|-------------------------------|------------------------|----------------------------------|----------------------|-------------------------------|
| Horn Type. | | Number PV | WMF | Hz |
| Height Above Tubesheet, ft | Integrated SPL, dB* | Integrated Sound Pressure, Pa | SPL at PWMF, dB* | Sound Pressure at PWMF, Pa |
| 25 10 | 135.0 | | | |
| 26 9 | 138.7 | | | |
| 27 8 | 138.7 | | | |
| 28 7 | 134.6 | | | |
| 29 6 | 131.2 | | | |
| 30 5 | 137.2 | | | |
| 31 4 | 139.8 | , , | | |
| 32) 3 | 138.3 | (138.3) | | |
| 33 2 | 135.3 | | | |
| 34 | 139.5 | | | |
| 35) 0 | 141.7 | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| - 127 1 1 1 1 1 1 1 | | | | |
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| ···· | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| Note: This form may be repro- | | <u> </u> | | |

Note. This form may be reproduced. * To convert to sound pressure $\rho = \rho_0 \log^{-1}(L_p/20)$

| Unit 2 Baghouse | Casing B | Compartment B2 | |
|------------------------------|--------------------------------|-----------------------|--|
| 10/11/91 15:30 Location E | Doors Open Purge Air Fan On | Three Horn Operation: | Two Horns in South Aisle and Horn near Door in North Aisle |

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 139.1 | 180.3 |
| 2 | 33 | 141.0 | 224.4 |
| 3 | 32 | 137.2 | 144.9 |
| 4 | 31 | 132.7 | 86.3 |
| 5 | 30 | 127.1 | 45.3 |
| 6 | 29 | 134.2 | 102.6 |
| 7 | 28 | 136.1 | 127.7 |
| 8 | 27 | 138.7 | 172.2 |
| 9 | 26 | 139.1 | 180.3 |
| 10 | 25 | 138.7 | 172.2 |
| 11 | 24 | 136.5 | 133.7 |
| 12 | 23 | 136.8 | 138.4 |
| 13 | 22 | 136.8 | 138.4 |
| 14 | 21 | 133.8 | 98.0 |
| 15 | 20 | 130.5 | 67.0 |
| 16 | 19 | 131.6 | 76.0 |
| 17 | 18 | 137.6 | 151.7 |
| 18 | 17 | 139.5 | 188.8 |
| 19 | 16 | 137.2 | 144.9 |
| 20 | 15 | 135.3 | 116.4 |
| 21 | 14 | 128.2 | 51.4 |
| 22 | 13 | 136.1 | 127.7 |
| 23 | 12 | 138.7 | 172.2 |
| 24 | 11 | 141.3 | 232.3 |
| 25 | 10 | 140.6 | 214.3 |
| 26 | 9 | 135.7 | 121.9 |
| 27 | 8 | 125.2 | 36.4 |
| 28 | 7 | 135.7 | 121.9 |
| 29 | 6 | 141.0 | 224.4 |
| 30 | 5 | 142.1 | 254.7 |
| 31 | 4 | 138.7 | 172.2 |
| 32 | 3 | 136.5 | 133.7 |
| 33 | 2 | 134.6 | 107.4 |
| 34 | 1 | 135.3 | 116.4 |
| 35 | 0 | 139.1 | 180.3 |

| Average Integrated | 137.0 | 141.6 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL) DATA SHEET COMPARTMENT BZ

FRIDAY, OCTOBER 11,1991 3:30 P.M.

3 HORD OPERATION

DOORS OPEN PURGE AIR FAN ON

LOCATION E

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 139.1 | |
| 2 | 33 | 141.0 | |
| 3_ | 32 | 137.2 | |
| 4 | 31 | 132.7 | |
| 5 | 30 | 127.1 | |
| 6 | 29 | 134.2 | |
| 7 | 28 | 136.1 | |
| 8 | 27 | 138.7 | |
| 9 | 26 | 139.1 | |
| 10 | 25 | 138.7 | |
| 11 | 24 | 136.5 | |
| (12) | 23 | 136.8 | |
| 13 | 22 | 136.8 | |
| 14 | 21 | 133.8 | |
| 15 | 20 | 130.5 | |
| (16) | 19 | 131.6 | |
| 17 | 18 | forgot to 137.6 | |
| 18 | 17 | Frun 139.5 | |
| 19 | 16 | 137.6 137.2 | |
| 20 | 15 | 135.3 135.3 | |
| 21 | 14 | 128.2 | |
| 22 | 13 | 136.1 | |
| 23 | 12 | 138.7 | |
| (24) | 11 | 141.3 | |
| 25 | 10 | 140.6 | |
| 26 | 9 | 135.7 | |
| 27 | 8 | 125.2 | |
| (28) | 7 | 135.7 | |
| 29 | 6 | 141.0 | |
| 30 | 5 | 142.1 | |
| 31 | 4 | 138.7 | |
| (32) | 3 | 136.8 Bb.5 | |
| 33 | 2 | 134.6 | |
| 34 | 1 | 135.3 | |
| (35) | 0 | 139.1 | |

| Unit 2 Baghouse | Casing B | Compartment B2 | _ |
|------------------------------|--------------------------------|-----------------------|--|
| 10/11/91 16:35 Location F | Doors Open Purge Air Fan On | Three Horn Operation: | Two Horns in South Aisle and Horn near Door in North Aisle |

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 139.8 | 195.4 |
| 2 | 33 | 136.8 | 138.4 |
| 3 | 32 | 132.7 | 86.3 |
| 4 | 31 | 134.6 | 107.4 |
| 5 | 30 | 137.6 | 151.7 |
| 6 | 29 | 140.2 | 204.7 |
| 7 | 28 | 139.5 | 188.8 |
| 8 | 27 | 141.7 | 243.2 |
| 9 | 26 | 142.1 | 254.7 |
| 10 | 25 | 142.1 | 254.7 |
| 11 | 24 | 139.5 | 188.8 |
| 12 | 23 | 141.3 | 232.3 |
| 13 | 22 | 142.5 | 266.7 |
| 14 | 21 | 142.8 | 276.1 |
| 15 | 20 | 140.6 | 214.3 |
| 16 | 19 | 141.0 | 224.4 |
| 17 | 18 | 141.7 | 243.2 |
| 18 | 17 | 142.8 | 276.1 |
| 19 | 16 | 141.7 | 243.2 |
| 20 | 15 | 144.7 | 343.6 |
| 21 | 14 | 144.7 | 343.6 |
| 22 | 13 | 142.8 | 276.1 |
| 23 | 12 | 138.3 | 164.4 |
| 24 | 11 | 141.7 | 243.2 |
| 25 | 10 | 143.6 | 302.7 |
| 26 | 9 | 144.0 | 317.0 |
| 27 | 8 | 139.8 | 195.4 |
| 28 | 7 | 136.5 | 133.7 |
| 29 | 6 | 135.3 | 116.4 |
| 30 | 5 | 139.1 | 180.3 |
| 31 | 4 | 138.3 | 164.4 |
| 32 | 3 | 138.3 | 164.4 |
| 33 | 2 | 133.8 | 98.0 |
| 34 | 1 | 134.2 | 102.6 |
| 35 | 0 | 136.5 | 133.7 |

| Average Integrated | 140.3 | 207.7 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

Friday October 11,1991

3 Horr Operation 4:35 p.m.

Doors Open: Purge Air Fan On

Location E Frank

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 139.8 | |
| 2 | 33 | 136.8 | |
| 3 | 32 | 132.7 | |
| 4) | 31 | 134.6 | |
| 5 | 30 | 137.6 | |
| 6 | 29 | 140.2 | |
| 7 | 28 | 139.5 | |
| (8) | 27 | 141.7 | |
| 9 | 26 | 142.1 | |
| 10 | 25 | 142.1 | |
| 11 | 24 | 139.5 | |
| (12) | 23 | 141.3 | |
| 13 | 22 | 142.5 | |
| 14 | 21 | 142.8 | |
| 15 | 20 | 140.6 | |
| (6) | 19 | 141.0 | |
| 17 | 18 | 141.7 | |
| 18 | 17 | 142.8 | |
| 19 | 16 | 141.7 | |
| (20) | 15 | 144.7 | |
| 21 | 14 | 144.7 | |
| 22 | 13 | 142.8 | |
| 23 | 12 | 138.3 | |
| (24) | 11 | 141.7 | |
| 25 | 10 | 143.6 | |
| 26 | 9 | 144.0 | 4 |
| 27 | 8 | 139.8 | |
| (28) | 7 | 136.5 | |
| 29 | 6 | 135.3 | |
| 30 | 5 | 139.1 | |
| 31 | 4 | 138.3 | |
| (32) | 3 | 138.7 (138.3) |) |
| 33 | 2 | 133.8 | |
| 34 | 1 | 134.2 | |
| (35) | O | 136.5 | |
| | | | |

| Unit 2 Baghouse | Casing B | Compartment B2 | |
|------------------------------|--------------------------------|-----------------------|--|
| 10/11/91 17:24 Location G | Doors Open Purge Air Fan On | Three Horn Operation: | Two Horns in South Aisle and Horn near Door in North Aisle |

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 139.1 | 180.3 |
| 2 | 33 | 140.2 | 204.7 |
| 3 | 32 | 136.1 | 127.7 |
| 4 | 31 | 135.0 | 112.5 |
| 5 | 30 | 138.7 | 172.2 |
| 6 | 29 | 140.2 | 204.7 |
| 7 | 28 | 137.2 | 144.9 |
| 8 | 27 | 136.1 | 127.7 |
| 9 | 26 | 138.0 | 158.9 |
| 10 | 25 | 141.0 | 224.4 |
| 11 | 24 | 139.5 | 188.8 |
| 12 | 23 | 139.1 | 180.3 |
| 13 | 22 | 137.6 | 151.7 |
| 14 | 21 | 136.5 | 133.7 |
| 15 | 20 | 138.0 | 158.9 |
| 16 | 19 | 141.7 | 243.2 |
| 17 | 18 | 143.2 | 289.1 |
| 18 | 17 | 141.7 | 243.2 |
| 19 | 16 | 138.7 | 172.2 |
| 20 | 15 | 139.8 | 195.4 |
| 21 | 14 | 144.7 | 343.6 |
| 22 | 13 | 145.1 | 359.8 |
| 23 | 12 | 142.1 | 254.7 |
| 24 | 11 | 142.8 | 276.1 |
| 25 | 10 | 141.3 | 232.3 |
| 26 | 9 | 140.2 | 204.7 |
| 27 | 8 | 139.1 | 180.3 |
| 28 | 7 | 142.5 | 266.7 |
| 29 | 6 | 142.8 | 276.1 |
| 30 | 5 | 140.6 | 214.3 |
| 31 | 4 | 134.6 | 107.4 |
| 32 | 3 | 133.5 | 94.6 |
| 33 | 2 | 141.0 | 224.4 |
| 34 | 1 | 140.6 | 214.3 |
| 35 | 0 | 142.8 | 276.1 |

| Average Integrated | 140.2 | 204.0 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

Friday October 11,1991 5:24 p.m.
Compartment B-2 Unit 2
3 Horn Operation
Doors Open: Purge Air Fan On

LOCATION G

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 139.1 | |
| 2 | 33 | 140.2 | |
| 3 | 32 | 136.1 | |
| 4 | 31 | 135.0 | |
| 5 | 30 | 138.7 | |
| 6 | 29 | 140.2 | |
| 7 | 28 | 137.2 | |
| 8 | 27 | 136.1 | |
| 9 | 26 | 138.0 | |
| 10 | 25 | 141.0 | |
| 11 | 24 | 139.5 | |
| (12) | 23 | 138.0 | |
| 13 | 22 | 137.6 | |
| 14 | 21 | 136.5 | |
| 15 | 20 | 138.0 | |
| (16) | 19 | 141.7 | |
| 17 | 18 | 143.2 | |
| 18 | 17 | 141.7 | |
| 19 | 16 | 138.7 | |
| (20) | 15 | 139.8 | |
| 21 | 14 | 144.7 | |
| 22 | 13 | 145.1 | |
| 23 | 12 | 142.1 | |
| 24) | 11 | 142.8 | |
| 25 | 10 | 141.3 | |
| 26 | 9 | 140.2 | • |
| 27 | 8 | 139.1 | |
| (28) | 7 | 142.5 | |
| 29 | 6 | 142.8 | |
| 30 | 5 | 140.6 | |
| 31 | 4 | 134.6 | |
| (32) | 3 | 133.5 136.1 | |
| 33 | 2 | 141.0 | |
| 34 | 1 | 140.6 | |
| 35 | 0 | 142.8 | |

| Unit 2 Baghouse | Casing B | Compartment B2 | _ |
|------------------------------|--------------------------------|-----------------------|--|
| 10/11/91 18:00 Location H | Doors Open Purge Air Fan On | Three Horn Operation: | Two Horns in South Aisle and Horn near Door in North Aisle |

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 139.8 | 195.4 |
| 2 | 33 | 141.7 | 243.2 |
| 3 | 32 | 138.0 | 158.9 |
| 4 | 31 | 134.6 | 107.4 |
| 5 | 30 | 130.5 | 67.0 |
| 6 | 29 | 136.1 | 127.7 |
| 7 | 28 | 136.5 | 133.7 |
| 8 | 27 | 138.3 | 164.4 |
| 9 | 26 | 139.5 | 188.8 |
| 10 | 25 | 138.7 | 172.2 |
| 11 | 24 | 135.7 | 121.9 |
| 12 | 23 | 135.0 | 112.5 |
| 13 | 22 | 132.7 | 86.3 |
| 14 | 21 | 130.8 | 69.3 |
| 15 | 20 | 130.8 | 69.3 |
| 16 | 19 | 133.1 | 90.4 |
| 17 | 18 | 135.0 | 112.5 |
| 18 | 17 | 135.0 | 112.5 |
| 19 | 16 | 133.8 | 98.0 |
| 20 | 15 | 133.8 | 98.0 |
| 21 | 14 | 131.6 | 76.0 |
| 22 | 13 | 132.3 | 82.4 |
| 23 | 12 | 132.3 | 82.4 |
| 24 | 11 | 131.6 | 76.0 |
| 25 | 10 | 131.6 | 76.0 |
| 26 | 9 | 133.8 | 98.0 |
| 27 | 8 | 132.7 | 86.3 |
| 28 | 7 | 133.5 | 94.6 |
| 29 | 6 | 130.8 | 69.3 |
| 30 | 5 | 130.8 | 69.3 |
| 31 | 4 | 132.3 | 82.4 |
| 32 | 3 | 134.2 | 102.6 |
| 33 | 2 | 135.0 | 112.5 |
| 34 | 1 | 132.7 | 86.3 |
| 35 | 0 | 137.6 | 151.7 |

| Average Integrated | 134.9 | 110.7 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

FRIDAY OCTOBER 11,1991 6:00p.m.

Compartment B-2 Unit Z

3 HORN Operation
Doors Open: Purge Air Fan On
Location H

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|------------------|-----------------|-------------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 139.8 | |
| 2 | 33 | 141.7 | |
| 3 | 32 | 138.0 | |
| (4) | 31 | 134.6 | |
| 5 | 30 | 130.5 | |
| 6 | 29 | 136.1 | |
| 7 | 28 | 136.5 | |
| 8 | 27 | 138.3 | |
| 9 | 26 | 139.5 | |
| 10 | 25 | 138.7 | |
| 11 | 24 | 135.7 | |
| (12) | 23 | 135.7 135.0 | |
| 13 | 22 | 132.7 | |
| 14 | 21 | 130.8 | |
| 15 | 20 | 130.8 | |
| (16) | 19 | 133.1 | |
| 17 | 18 | 135.0 | |
| 18 | 17 | 135.0 | |
| 19 | 16 | 133.8 | |
| (20) | 15 | 133.8 | |
| 21 | 14 | 131.6 | |
| 22 | 13 | 132.3 | |
| 23 | 12 | 132.3 | |
| (24) | 11 | 131.6 | |
| 25 | 10 | 131.6 | |
| 26 | 9 | 133.8 | • |
| 27 | 8 | 132.7 | |
| (28) | 7 | 133.5 | |
| 29 | 6 | 130.8 | |
| 30 | 5 | 130.8 | |
| 31 (32) 33 | 4 | 132.3 | |
| (32) | 3 | 134.2(134.6 |) |
| 33 | 2 | 135.0 | |
| 34 (35) | 1 | 132.7 | |
| <u>/35</u>) | 0 | 135.0 132.7 137.6 | |

Unit 2 Baghouse Casing B Compartment B2

10/12/91 16:30 Doors Open Three Horn Operation: Two Horns in South Aisle and Horn near Door in North Aisle

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 135.7 | 121.9 |
| 2 | 33 | 134.2 | 102.6 |
| 3 | 32 | 133.1 | 90.4 |
| 4 | 31 | 135.0 | 112.5 |
| 5 | 30 | 136.5 | 133.7 |
| 6 | 29 | 135.0 | 112.5 |
| 7 | 28 | 129.7 | 61.1 |
| 8 | 27 | 132.7 | 86.3 |
| 9 | 26 | 137.6 | 151.7 |
| 10 | 25 | 139.1 | 180.3 |
| 11 | 24 | 136.5 | 133.7 |
| 12 | 23 | 136.1 | 127.7 |
| 13 | 22 | 137.2 | 144.9 |
| 14 | 21 | 138.7 | 172.2 |
| 15 | 20 | 135.7 | 121.9 |
| 16 | 19 | 132.0 | 79.6 |
| 17 | 18 | 126.3 | 41.3 |
| 18 | 17 | 130.8 | 69.3 |
| 19 | 16 | 133.8 | 98.0 |
| 20 | 15 | 133.8 | 98.0 |
| 21 | 14 | 132.7 | 86.3 |
| 22 | 13 | 135.0 | 112.5 |
| 23 | 12 | 135.3 | 116.4 |
| 24 | 11 | 137.6 | 151.7 |
| 25 | 10 | 135.7 | 121.9 |
| 26 | 9 | 133.8 | 98.0 |
| 27 | 8 | 134.6 | 107.4 |
| 28 | 7 | 136.5 | 133.7 |
| 29 | 6 | 138.3 | 164.4 |
| 30 | 5 | 138.7 | 172.2 |
| 31 | 4 | 136.5 | 133.7 |
| 32 | 3 | 136.1 | 127.7 |
| 33 | 2 | 138.0 | 158.9 |
| 34 | 1 | 137.2 | 144.9 |
| 35 | 0 | 139.8 | 195.4 |

| Average Integrated | 135.7 | 121.8 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL) DATA SHEET Saturdy October 12,1991 4:30 p.m

Location I IKE

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|---|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 135.7 | |
| 2 | 33 | 134.2 | |
| 3 | 32 | 133.1 | |
| 3 4 | 31 | 135.0 | |
| 5 | 30 | 136.5 | |
| 6 | 29 | 135.0 | |
| 7 | 28 | 129.7 | |
| 8 | 27 | 132.7 | |
| 9 | 26 | 137.6 | |
| 10 | 25 | 139.1 | |
| 11 | 24 | 136.5 | |
| (2) | 23 | 136.1 | |
| 13 | 22 | 137.2 | |
| 14 | 21 | 138.7 | |
| 15 | 20 | 135.7 | |
| 16) | 19 | 132.0 | |
| 17 | 18 | 126.3 | |
| 18 | 17 | 130.8 | |
| 19 | 16 | 133.8 | |
| (20) | 15 | 133.8 | |
| 21 | 14 | 132.7 | |
| 22 | 13 | 135.0 | |
| 23 | 12 | 135.3 | |
| 24 | 11 | 137.6 | |
| 25 | 10 | 135.7 | |
| 26 | 9 | 133.8 | 4 |
| 27 | 8 | 134.6 | |
| (28) | 7 | 136.5 | |
| 29 | 6 | 138.3 | |
| 30 | 5 | 138.7 | |
| 31 (32) | 4 | 136.5 | |
| | 3 | 137.2 (136.1 |) |
| 33 | 2 | 138.0 | |
| 34 | 1 | 136.5 137.2 (136.1) 138.0 137.2 139.8 | |
| (35) | 0. | 139.8 | |

| Unit 2 Baghouse | Casing B | Compartment B2 | |
|------------------------------|--------------------------------|-----------------------|--|
| 10/12/91 15:00 Location J | Doors Open Purge Air Fan On | Three Horn Operation: | Two Horns in South Aisle and Horn near Door in North Aisle |

| Distance Below Hook, feet | Height Above Tubesheet, feet | Integrated Sound Pressure Level, dB | Integrated Sound Pressure, Pa |
|------------------------------|---------------------------------|--|----------------------------------|
| 1 | 34 | 140.6 | 214.3 |
| 2 | 33 | 142.5 | 266.7 |
| 3 | 32 | 136.8 | 138.4 |
| 4 | 31 | 128.6 | 53.8 |
| 5 | 30 | 135.0 | 112.5 |
| 6 | 29 | 139.5 | 188.8 |
| 7 | 28 | 138.7 | 172.2 |
| 8 | 27 | 140.2 | 204.7 |
| 9 | 26 | 140.6 | 214.3 |
| 10 | 25 | 139.8 | 195.4 |
| 11 | 24 | 136.5 | 133.7 |
| 12 | 23 | 138.7 | 172.2 |
| 13 | 22 | 137.6 | 151.7 |
| 14 | 21 | 136.1 | 127.7 |
| 15 | 20 | 132.0 | 79.6 |
| 16 | 19 | 134.6 | 107.4 |
| 17 | 18 | 135.7 | 121.9 |
| 18 | 17 | 137.6 | 151.7 |
| 19 | 16 | 138.0 | 158.9 |
| 20 | 15 | 139.1 | 180.3 |
| 21 | 14 | 136.1 | 127.7 |
| 22 | 13 | 135.3 | 116.4 |
| 23 | 12 | 133.8 | 98.0 |
| 24 | 11 | 137.6 | 151.7 |
| 25 | 10 | 141.0 | 224.4 |
| 26 | 9 | 141.7 | 243.2 |
| 27 | 8 | 139.5 | 188.8 |
| 28 | 7 | 139.1 | 180.3 |
| 29 | 6 | 137.6 | 151.7 |
| 30 | 5 | 140.6 | 214.3 |
| 31 | 4 | 139.8 | 195.4 |
| 32 | 3 | 141.0 | 224.4 |
| 33 | 2 | 142.8 | 276.1 |
| 34 | 1 | 141.3 | 232.3 |
| 35 | 0 | 142.5 | 266.7 |

| Average Integrated | 138.7 | 172.5 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

Saturday October 12, 1991 3:00

Location I

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|------------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 140.6 | |
| 2 | 33 | 142.5 | |
| 3 | 32 | 136.B | |
| (4) | 31 | 128.6 | |
| 5 | 30 | 135.0 | |
| 6 | 29 | 139.5 | |
| 7 | 28 | 138.7 | |
| (8) | 27 | 140.2 | |
| 9 | 26 | 140.6 | |
| 10 | 25 | 139.8 | |
| 11 | 24 | 136.5 | |
| (12) | 23 | 138.7 | |
| 13 | 22 | 137.6 | |
| 14 | 21 | 136.1 | |
| 15 | 20 | 132.0 | |
| (16) | 19 | 134.6 | |
| 17 | 18 | 135.7 | |
| 18 | 17 | 137.6 | |
| 19 | 16 | 138.0 | |
| (20) | 15 | 139. | |
| 21 | 14 | 136.1 | |
| 22 | 13 | 135.3 | |
| 23 | 12 | 133.8 | |
| 24 | 11 | 137.6 | |
| 25 | 10 | 141.0 | |
| 26 | 9 | 141.7 | • |
| 27 | 8 | 139.5 | |
| 28 | 7 | 139.1 | |
| 29 | 6 | 137.6 | |
| 30 | 5 | 140.6 | |
| 31 | 4 | 139.8 | |
| (32) | 3 | 141.7 (141.0) | |
| 33 | 2 | 142.8 | |
| 34 | 1 | 141.3 | |
| (35) | 0 | 142.5 | |

Unit 2 Baghouse Casing B Compartment B2

10/12/91 11:15 Doors Open Three Horn Operation: Two Horns in South Aisle and Horn near Door in North Aisle

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 131.2 | 72.6 |
| 2 | 33 | 133.1 | 90.4 |
| 3 | 32 | 133.8 | 98.0 |
| 4 | 31 | 135.1 | 113.8 |
| 5 | 30 | 130.1 | 64.0 |
| 6 | 29 | 135.7 | 121.9 |
| 7 | 28 | 136.8 | 138.4 |
| 8 | 27 | 139.8 | 195.4 |
| 9 | 26 | 141.0 | 224.4 |
| 10 | 25 | 141.0 | 224.4 |
| 11 | 24 | 136.8 | 138.4 |
| 12 | 23 | 136.1 | 127.7 |
| 13 | 22 | 135.3 | 116.4 |
| 14 | 21 | 132.7 | 86.3 |
| 15 | 20 | 130.8 | 69.3 |
| 16 | 19 | 133.1 | 90.4 |
| 17 | 18 | 134.2 | 102.6 |
| 18 | 17 | 134.2 | 102.6 |
| 19 | 16 | 133.8 | 98.0 |
| 20 | 15 | 135.7 | 121.9 |
| 21 | 14 | 137.6 | 151.7 |
| 22 | 13 | 138.0 | 158.9 |
| 23 | 12 | 135.7 | 121.9 |
| 24 | 11 | 133.5 | 94.6 |
| 25 | 10 | 131.6 | 76.0 |
| 26 | 9 | 130.1 | 64.0 |
| 27 | 8 | 127.1 | 45.3 |
| 28 | 7 | 128.2 | 51.4 |
| 29 | 6 | 134.2 | 102.6 |
| 30 | 5 | 137.2 | 144.9 |
| 31 | 4 | 136.5 | 133.7 |
| 32 | 3 | 137.2 | 144.9 |
| 33 | 2 | 136.5 | 133.7 |
| 34 | 1 | 130.8 | 69.3 |
| 35 | 0 | 133.5 | 94.6 |

| Average Integrated | 135.1 | 113.8 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

Saturday October 12, 1991 11:15 A.M.
Compartment B2 - Unit Z
3 Horn Operation
Doors Open: Purge air Fan On
Location K

| Height Above | Integrated Sound | Integrated Sound |
|-----------------|--|------------------|
| Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 34 | 131.2 | |
| 33 | 133.1 | |
| 32 | 133.8 | |
| 31 | 135.1 | |
| 30 | 130.1 | |
| 29 | | |
| 28 | | |
| 27 | | |
| 26 | | |
| 25 | 141.0 | |
| 24 | | |
| 23 | | |
| 22 | 135.3 | |
| 21 | 132.7 | |
| 20 | | |
| 19 | 133.1 | |
| 18 | 134.2 | |
| 17 | 134.2 | |
| 16 | | |
| 15 | 135.7 | |
| 14 | 137.6 | |
| 13 | 138.0 | |
| 12 | 135.7 | |
| 11 | 133.5 | |
| 10 | 131.6 | |
| 9 | 130.1 | • |
| 8 | | |
| 7 | 128.7 | |
| 6 | 134.2 | |
| 5 | 137.2 | |
| 4 | 136.5 | |
| 3 | 137.2 137.6 | |
| 2 | 136.5 | |
| 1 | 130.8 | |
| 0 | 133.5 | |
| | Tubesheet, feet 34 33 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 | Tubesheet, feet |

| Unit 2 Baghouse | Casing B | Compartment B2 | _ |
|-----------------------------|--------------------------------|-----------------------|--|
| 9/29/91 18:00 Location L | Doors Open Purge Air Fan On | Three Horn Operation: | Two Horns in South Aisle and Horn near Door in North Aisle |

| Reet, feet 34 33 32 31 30 29 28 27 26 25 24 23 | Pressure Level, dB 132.3 138.0 137.2 133.5 131.2 132.7 133.5 133.1 135.3 136.1 | Pressure, Pa 82.4 158.9 144.9 94.6 72.6 86.3 94.6 90.4 90.4 116.4 127.7 |
|--|--|--|
| 33 32 31 30 29 28 27 26 25 | 138.0 137.2 133.5 131.2 132.7 133.5 133.1 133.1 135.3 136.1 | 158.9 144.9 94.6 72.6 86.3 94.6 90.4 90.4 |
| 32 31 30 29 28 27 26 25 24 | 137.2 133.5 131.2 132.7 133.5 133.1 133.1 135.3 136.1 | 144.9 94.6 72.6 86.3 94.6 90.4 90.4 |
| 31 30 29 28 27 26 25 24 | 133.5 131.2 132.7 133.5 133.1 133.1 135.3 136.1 | 94.6 72.6 86.3 94.6 90.4 90.4 |
| 30 29 28 27 26 25 24 | 131.2 132.7 133.5 133.1 133.1 135.3 136.1 | 72.6 86.3 94.6 90.4 90.4 116.4 |
| 29 28 27 26 25 24 | 132.7 133.5 133.1 133.1 135.3 136.1 | 86.3 94.6 90.4 90.4 116.4 |
| 28 27 26 25 24 | 133.5 133.1 133.1 135.3 136.1 | 94.6 90.4 90.4 116.4 |
| 27 26 25 24 23 | 133.1 133.1 135.3 136.1 | 90.4 90.4 116.4 |
| 26 25 24 23 | 133.1 135.3 136.1 | 90.4 116.4 |
| 25 24 23 | 135.3 136.1 | 116.4 |
| 24 23 | 136.1 | |
| 23 | | 1 1777 |
| | | |
| 22 | 134.2 | 102.6 |
| | 130.1 | 64.0 |
| 21 | 127.8 | 49.1 |
| 20 | 128.6 | 53.8 |
| 19 | 128.6 | 53.8 |
| 18 | 129.0 | 56.4 |
| 17 | 130.5 | 67.0 |
| 16 | 130.5 | 67.0 |
| 15 | 130.5 | 67.0 |
| 14 | 134.2 | 102.6 |
| 13 | 136.8 | 138.4 |
| 12 | 136.5 | 133.7 |
| 11 | 133.5 | 94.6 |
| · · · · · · · · · · · · · · · · · · · | | 51.4 |
| | | 76.0 |
| | | 127.7 |
| | | 144.9 |
| | | 116.4 |
| | | 112.5 |
| | | 86.3 |
| the second second | | 69.3 |
| | | 98.0 |
| _ ' | | 94.6 |
| | | 82.4 |
| 1 | 10 9 8 7 6 5 4 3 2 | 10 128.2 9 131.6 8 136.1 7 137.2 6 135.3 5 135.0 4 132.7 3 130.8 2 133.8 1 133.5 |

| 133.4 | 93.4 |
|----------|---------|
| Decibals | Pascals |
| | |

DATA FORM BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL)

BAGHO

Shows

Date 9/29/91

Door open Theight Ahren

Pury _ Measurement Position. Compartment. _ PWMF Number _ Sound Pressure at PWMF, Pa SPL at PWMF, dB* Integrated Sound Pressure, Pa Integrated SPL, dB* 132.3 1 138.0 2 33 137.2 32 133.5 31 131.2 30 132.7 29 133.5 28 133.1 27 33.1 26 9 135.3 25 10 136.1 24 134.2 12 22 30. 127.8 21 128.6 15 20 19 128.6 129.0 18 17 130,5 17 18 130.5 16 130.5 15 20 14 134.2 21 13 136.8 22 136.5

Note This form may be reproduced

23

133.5

12

11

To convert to sound pressure. $p = p_0 \log^{-1}(L_p/20)$

DATA FORM BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL)

BAGH

Doors Open On Date 9/29/91

Pury aur Fau On Date 9/29/91

| Date _ | 29/91 | Compartment | B-2 | Measurement Positi | on. |
|-----------------|-----------------------|------------------------|----------------------------------|---------------------|-------------------------------|
| Horn Type _ | | +. <u></u> | Number | PWMF. | Hz |
| Heigh Tube | ht Above sheet, ft | Integrated SPL, dB* | Integrated Sound Pressure, Pa | SPL at PWMF, dB* | Sound Pressure at PWMF, Pa |
| 255 | 10 | 128.2 | | | |
| 26 | 9 | 131.6 | · | | |
| - 0 | 8 | 136.1 | | | |
| 27 28) 29 | | 137.2 | | | |
| 29 | Ь | 135.3 | | | |
| 30 | | 135.0 | | | |
| 3 | Ч | 132.7 | | | |
| 32 | 3 | 131.6 | (130,8) | | |
| 33 | 2 | 133.8 | ĺ . | | |
| 34 | | 133.5 | | | |
| (35) | 0 | 132.3 | | | |
| | | | | | / |
| | | | | | |
| | | | | | |
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| - | | | | | |
| | | <u> </u> | <u> </u> | | |

Note This form may be reproduced *To convert to sound pressure: $\rho = \rho_0 \log^{-1}(L_p/20)$

| Unit 2 Baghouse | Casing B | Compartment B2 | |
|-----------------------------|--------------------------------|-----------------------|--|
| 9/29/91 19:00 Location M | Doors Open Purge Air Fan On | Three Horn Operation: | Two Horns in South Aisle and Horn near Door in North Aisle |

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 136.1 | 127.7 |
| 2 | 33 | 134.6 | 107.4 |
| 3 | 32 | 133.5 | 94.6 |
| 4 | 31 | 135.3 | 116.4 |
| 5 | 30 | 135.0 | 112.5 |
| 6 | 29 | 136.8 | 138.4 |
| 7 | 28 | 136.1 | 127.7 |
| 8 | 27 | 132.7 | 86.3 |
| 9 | 26 | 127.8 | 49.1 |
| 10 | 25 | 130.1 | 64.0 |
| 11 | 24 | 133.8 | 98.0 |
| 12 | 23 | 135.3 | 116.4 |
| 13 | 22 | 135.0 | 112.5 |
| 14 | 21 | 136.8 | 138.4 |
| 15 | 20 | 139.1 | 180.3 |
| 16 | 19 | 139.1 | 180.3 |
| 17 | 18 | 137.2 | 144.9 |
| 18 | 17 | 138.7 | 172.2 |
| 19 | 16 | 139.1 | 180.3 |
| 20 | 15 | 138.0 | 158.9 |
| 21 | 14 | 133.8 | 98.0 |
| 22 | 13 | 133.8 | 98.0 |
| 23 | 12 | 137.2 | 144.9 |
| 24 | 11 | 139.1 | 180.3 |
| 25 | 10 | 138.3 | 164.4 |
| 26 | 9 | 140.6 | 214.3 |
| 27 | 8 | 138.7 | 172.2 |
| 28 | 7 | 134.6 | 107.4 |
| 29 | 6 | 131.6 | 76.0 |
| 30 | 5 | 135.0 | 112.5 |
| 31 | 4 | 137.6 | 151.7 |
| 32 | 3 | 137.6 | 151.7 |
| 33 | 2 | 138.7 | 172.2 |
| 34 | 1 | 139.1 | 180.3 |
| 35 | 0 | 139.1 | 180.3 |

| Average Integrated | 136.6 | 134.6 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

BHows Open on Purgedin For On 7:00 P.M

DATA FORM BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL)

| Sun 9/29/91 | 0.0 | m |
|-------------|------------------|----------------------|
| Date. | Compartment. B M | Measurement Position |

| Horn Type | | | Number PV | VMF | Hz |
|----------------|---------------------------|------------------------|----------------------------------|---------------------|-------------------------------|
| He | ight Above besheet, ft | Integrated SPL, dB* | Integrated Sound Pressure, Pa | SPL at PWMF, dB* | Sound Pressure at PWMF, Pa |
| 1 | 34 | 136.1 | | | |
| 2 | 33 | 134.6 | | | |
| 3 | 32 | 133.5 | | | |
| 9 | 31 | 135.3 | | | |
| 5 | 30 | 135.0 | | | |
| 6 | 29 | 136.8 | | | |
| 7 | 28 | 136.1 | | | |
| (8) | 27 | 132.7 | | | |
| 9 | 26 | 127.8 | | | |
| 10 | 25 | 130.1 | | | |
| | 24 | 133.8 | | | |
| (P)_ | 23 | 136.3 | | | |
| 13 | 22 | 135.0 | | | |
| 14 | 2. | 136.8 | | | |
| 15 | 70 | 139.1 | | | |
| (16) | 19 | 139.1 | | | |
| 17 | 18 | 137.2 | | | |
| 18 | 17 | 138.7 | | | |
| 9 | 16 | 139.1 | | | |
| (2 <u>0</u>)_ | 15 | 138.0 | | | |
| 21 | 14 | 133.8 | | | |
| 22_ | 13 | 133.8 | | | |
| 23 | 12 | 137.2 | | | |
| (29) | | 139.1 | | | - |
| 9 | | | | | |

Note: This form may be reproduced *To convert to sound pressure $\rho = \rho_0 \log^{-1}(L_p/20)$

DATA FORM

| DO sus | | | BAGHOU | ISE COMPAR | TMENT SOUND F | PRESSURE LEV | EL (SPL) |
|--------|------------|---|---------------------|------------------------|--|----------------------|-------------------------------|
| | pen for Dr | Sun Date $9/7$ | 29/91 | Compartment | B-2 | Measurement Position | n: |
| Descri | air tou | Horn Type _ | | | Number P | WMF | H |
| Pury | | Heigh Tubes | t Above heet, ft | Integrated SPL, dB* | Integrated Sound Pressure, Pa | SPL at PWMF, dB* | Sound Pressure at PWMF, Pa |
| , 0 | | 25 | 10 | 138.3 | | | |
| | | 26 | 9 | 140.6 | | | |
| | | 27 | Ź | 138.7 | | | |
| | | (28) | 7 | 134.6 | | | |
| | | 29 | 6 | 131.6 | | | |
| | | 30 | 5 | 135.0 | | | |
| | | 31 | 4 | 137.6 | | | |
| | | (32) | 3 | 138.3 | (137.6 | | |
| | | 33 | 2 | 138.7 | | | |
| | | 34 | 1 | 139.1 | | | |
| | | (35) | 0 | 139.1 | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
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| | | | | | | | |
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| | | · | | | | | |

Note This form may be reproduced *To convert to sound pressure: $p = p_0 \log^{-1}(L_p/20)$

Unit 2 Baghouse Casing B Compartment B2

10/12/91 17:15 Doors Open Three Horn Operation: Two Horns in South Aisle and Horn near Door in North Aisle

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 135.3 | 116.4 |
| 2 | 33 | 139.5 | 188.8 |
| 3 | 32 | 136.8 | 138.4 |
| 4 | 31 | 136.1 | 127.7 |
| 5 | 30 | 137.2 | 144.9 |
| 6 | 29 | 138.0 | 158.9 |
| 7 | 28 | 137.6 | 151.7 |
| 8 | 27 | 139.1 | 180.3 |
| 9 | 26 | 138.3 | 164.4 |
| 10 | 25 | 139.5 | 188.8 |
| 11 | 24 | 136.8 | 138.4 |
| 12 | 23 | 134.6 | 107.4 |
| 13 | 22 | 129.3 | 58.3 |
| 14 | 21 | 134.6 | 107.4 |
| 15 | 20 | 136.8 | 138.4 |
| 16 | 19 | 139.1 | 180.3 |
| 17 | 18 | 137.6 | 151.7 |
| 18 | 17 | 130.8 | 69.3 |
| 19 | 16 | 131.2 | 72.6 |
| 20 | 15 | 138.0 | 158.9 |
| 21 | 14 | 141.7 | 243.2 |
| 22 | 13 | 141.3 | 232.3 |
| 23 | 12 | 135.3 | 116.4 |
| 24 | 11 | 134.6 | 107.4 |
| 25 | 10 | 140.2 | 204.7 |
| 26 | 9 | 143.6 | 302.7 |
| 27 | 8 | 142.1 | 254.7 |
| 28 | 7 | 143.2 | 289.1 |
| 29 | 6 | 141.0 | 224.4 |
| 30 | 5 | 139.1 | 180.3 |
| 31 | 4 | 136.8 | 138.4 |
| 32 | 3 | 141.3 | 232.3 |
| 33 | 2 | 145.5 | 376.7 |
| 34 | 1 | 143.6 | 302.7 |
| 35 | 0 | 145.8 | 390.0 |

| Average Integrated | 139.1 | 181.1 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

Saturday October 12,1991 5:15 p.m.

| Locatio | NN | Nancy | |
|---------------|-----------------|--------------|-----|
| istance Below | Height Above | Integrated | s |
| Hook, feet | Tubesheet, feet | Pressure Lev | /el |

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 135.3 | |
| 2 | 33 | 139.5 | |
| 3 | 32 | 136.8 | |
| 3 (4) | 31 | 136.1 | |
| 5 | 30 | 137.2 | |
| 6 | 29 | 138.0 | |
| 7 | 28 | 137.6 | |
| 8 | 27 | 139.1 | |
| 9 | 26 | 138.3 | |
| 10 | 25 | 139.5 | |
| 11 | 24 | 136.8 | |
| (12) | 23, | 134.6 | |
| 13 | 22 | 129.3 | |
| 14 | 21 | 134.6 | |
| 15 | 20 | 136.8 | |
| (16) | 19 | 139.1 | |
| 17 | 18 | 137.6 | |
| 18 | 17 | 130.8 | |
| 19 | 16 | 131.2 | |
| (20) | 15 | 138.0 | |
| 21 | 14 | 141.7 | |
| 22 | 13 | 141.3 | |
| 23 | 12. | 135.7 | |
| (24) | 11 | 134.6 | |
| 25 | 10 | 140.2 | |
| 26 | 9 | 143.6 | - |
| 27 | 8 | 142. | |
| (28) | 7 | 143.2 | |
| 29 | 6 | 141.0 | |
| 30 | 5 | 139.1 | |
| 31_ | 4 | 136.8,18 | |
| (32) | 3 | 141.3(143.2) | |
| 33 | 2 | 145.5 | |
| 34 | 1 | 143.6 | |
| (35) | 0 | 145.8 | |

Unit 2 Baghouse Casing B Compartment B2

10/12/91 18:00 Doors Open Three Horn Operation: Two Horns in South Aisle and Horn near Door in North Aisle

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 132.7 | 86.3 |
| 2 | 33 | 131.6 | 76.0 |
| 3 | 32 | 133.8 | 98.0 |
| 4 | 31 | 136.8 | 138.4 |
| 5 | 30 | 138.0 | 158.9 |
| 6 | 29 | 138.3 | 164.4 |
| 7 | 28 | 136.1 | 127.7 |
| 8 | 27 | 136.1 | 127.7 |
| 9 | 26 | 135.7 | 121.9 |
| 10 | 25 | 135.0 | 112.5 |
| 11 | 24 | 133.1 | 90.4 |
| 12 | 23 | 132.7 | 86.3 |
| 13 | 22 | 133.8 | 98.0 |
| 14 | 21 | 135.3 | 116.4 |
| 15 | 20 | 133.5 | 94.6 |
| 16 | 19 | 132.3 | 82.4 |
| 17 | 18 | 130.8 | 69.3 |
| 18 | 17 | 132.0 | 79.6 |
| 19 | 16 | 134.2 | 102.6 |
| 20 | 15 | 136.8 | 138.4 |
| 21 | 14 | 136.5 | 133.7 |
| 22 | 13 | 135.0 | 112.5 |
| 23 | 12 | 131.6 | 76.0 |
| 24 | 11 | 134.2 | 102.6 |
| 25 | 10 | 138.7 | 172.2 |
| 26 | 9 | 142.1 | 254.7 |
| 27 | 8 | 140.2 | 204.7 |
| 28 | 7 | 139.8 | 195.4 |
| 29 | 6 | 133.8 | 98.0 |
| 30 | 5 | 137.2 | 144.9 |
| 31 | 4 | 138.3 | 164.4 |
| 32 | 3 | 141.7 | 243.2 |
| 33 | 2 | 142.1 | 254.7 |
| 34 | 1 | 139.1 | 180.3 |
| 35 | 0 | 140.2 | 204.7 |

| Average Integrated | 136.6 | 134.6 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL) DATA SHEET Saturday October 12, 1991 6:00 P.M

Location Octopus

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 132.7 | |
| 2 | 33 | 131.6 | |
| 3 | 32 | 133.8 | |
| 4 | 31 | 136.8 | |
| 5 | 30 | 138.0 | |
| 6 | 29 | 138.3 | |
| 7 | 28 | 136.1 | |
| 8 | 27 | 36.1 | |
| 9 | 26 | 135.7 | |
| 10 | 25 | 135.0 | |
| 11 | 24 | 133.1 | |
| (12) | 23 | 132.7 | |
| 13 | 22 | 133.8 | |
| 14 | 21 | 135.3 | |
| 15 | 20 | 133.5 | |
| (16) | 19 | 132.3 | |
| 17 | 18 | 130.8 | |
| 18 | 17 | 132.0 | |
| 19 | 16 | 134.2 | |
| (20) | 15 | 136.8 | |
| 21 | 14 | 136.5 | |
| 22 | 13 | 135.0 | |
| 23 | 12 | 131.6 | |
| (24) | 11 | 134.2 | |
| 25 | 10 | 133.7 | |
| 26 | 9 | 142.1 | • |
| 27 | 8 | 140.2 | |
| (28) | 7 | 139.8 | |
| 29 | 6 | 133.8 | |
| 30 | 5 | 137.2 | |
| 31 | 4 | 138.3 | |
| 32 | 3 | 141.7(142.1) | |
| 33 | 2 | 142.1 | |
| 34 | 1 | 139.1 | |
| (35) | 0 | 140.2 | |

| Unit 2 Baghouse | Casing B | Compartment B2 | |
|------------------------------|--------------------------------|-----------------------|--|
| 10/13/91 19:30 Location P | Doors Open Purge Air Fan On | Three Horn Operation: | Two Horns in South Aisle and Horn near Door in North Aisle |

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 135.0 | 112.5 |
| 2 | 33 | 134.2 | 102.6 |
| 3 | 32 | 133.8 | 98.0 |
| 4 | 31 | 134.2 | 102.6 |
| 5 | 30 | 130.1 | 64.0 |
| 6 | 29 | 131.6 | 76.0 |
| 7 | 28 : | 135.3 | 116.4 |
| 8 | 27 | 139.5 | 188.8 |
| 9 | 26 | 142.1 | 254.7 |
| 10 | 25 | 142.8 | 276.1 |
| 11 | 24 | 139.5 | 188.8 |
| 12 | 23 | 138.0 | 158.9 |
| 13 | 22 | 132.0 | 79.6 |
| 14 | 21 | 128.6 | 53.8 |
| 15 | 20 | 129.7 | 61.1 |
| 16 | 19 | 133.8 | 98.0 |
| 17 | 18 | 137.6 | 151.7 |
| 18 | 17 | 139.5 | 188.8 |
| 19 | 16 | 136.5 | 133.7 |
| 20 | 15 | 132.3 | 82.4 |
| 21 | 14 | 130.8 | 69.3 |
| 22 | 13 | 136.5 | 133.7 |
| 23 | 12 | 138.3 | 164.4 |
| 24 | 11 | 140.2 | 204.7 |
| 25 | 10 | 136.1 | 127.7 |
| 26 | 9 | 135.3 | 116.4 |
| 27 | 8 | 134.6 | 107.4 |
| 28 | 7 | 135.3 | 116.4 |
| 29 | 6 | 138.0 | 158.9 |
| 30 | 5 | 139.1 | 180.3 |
| 31 | 4 | 136.8 | 138.4 |
| 32 | 3 | 138.0 | 158.9 |
| 33 | 2 | 139.1 | 180.3 |
| 34 | 1 | 138.0 | 158.9 |
| 35 | 0 | 142.1 | 254.7 |

| Average Integrated | 136.8 | 138.8 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

Sunday October 13, 1991 7:30 P.M.

LOCATION P Pain

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|-------------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 135.0 | |
| 2 | 33 | 134.2 | |
| 3 | 32 | 133.8 | |
| (4) | 31 | 134.2 | |
| 5 | 30 | 130.1 | |
| 6 | 29 | 131.6 | |
| 7 | 28 | 135.3 | |
| 8 | 27 | 139.5 | |
| 9 | 26 | 142.1 | |
| 10 | 25 | 142.8 | |
| 11 | 24 | 139.5 | |
| (12) | 23 | 138.0 | |
| 13 | 22 | 132.0 | |
| 14 | 21 | 128.6 | |
| 15 | 20 | 129.7 | |
| (16) | 19 | 133.8 | |
| 17 | 18 | 137.6 | |
| 18 | 17 | 139.5 | |
| 19 | 16 | 136.5 | |
| 20 | 15 | 132.3 | |
| 21 | 14 | 130.8 | |
| 22 | 13 | 136.5 | |
| 23 | 12 | 138.3 | |
| (24) | 11 | 40.2 | |
| 25 | 10 | 136. | |
| 26 | 9 | 135.3 | * |
| 27 | 8 | ط ، 134 | |
| 28 | 7 | 135.3 | |
| 29 | 6 | 138.0 | |
| 30 | 5 | 139.1 | |
| 31 | 4 | 136.8 | |
| (32) | 3 | 136.8 | |
| 33 | 2 | 139.1 | |
| 34 | 1 | 138.0 | |
| (35) | 0 | 139.1 138.0 142.1 | |
| | | | |

| Unit 2 Baghouse | Casing B | Compartment B2 | _ |
|------------------------------|--------------------------------|-----------------------|--|
| 10/13/91 18:45 Location Q | Doors Open Purge Air Fan On | Three Horn Operation: | Two Horns in South Aisle and Horn near Door in North Aisle |

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 144.0 | 317.0 |
| 2 | 33 | 144.3 | 328.1 |
| 3 | 32 | 138.7 | 172.2 |
| 4 | 31 | 135.7 | 121.9 |
| 5 | 30 | 136.8 | 138.4 |
| 6 | 29 | 141.0 | 224.4 |
| 7 | 28 | 139.8 | 195.4 |
| 8 | 27 | 141.0 | 224.4 |
| 9 | 26 | 140.6 | 214.3 |
| 10 | 25 | 143.6 | 302.7 |
| 11 | 24 | 142.5 | 266.7 |
| 12 | 23 | 144.3 | 328.1 |
| 13 | 22 | 144.0 | 317.0 |
| 14 | 21 | 141.7 | 243.2 |
| 15 | 20 | 138.7 | 172.2 |
| 16 | 19 | 141.0 | 224.4 |
| 17 | 18 | 143.2 | 289.1 |
| 18 | 17 | 141.7 | 243.2 |
| 19 | 16 | 140.2 | 204.7 |
| 20 | 15 | 142.1 | 254.7 |
| 21 | 14 | 143.6 | 302.7 |
| 22 | 13 | 143.2 | 289.1 |
| 23 | 12 | 139.1 | 180.3 |
| 24 | 11 | 140.6 | 214.3 |
| 25 | 10 | 142.1 | 254.7 |
| 26 | 9 | 142.5 | 266.7 |
| 27 | 8 | 138.3 | 164.4 |
| 28 | 7 | 136.1 | 127.7 |
| 29 | 6 | 136.8 | 138.4 |
| 30 | 5 | 139.5 | 188.8 |
| 31 | 4 | 138.7 | 172.2 |
| 32 | 3 | 138.0 | 158.9 |
| 33 | 2 | 135.0 | 112.5 |
| 34 | 1 | 132.7 | 86.3 |
| 35 | 0 | 138.0 | 158.9 |

| Average Integrated | 140.7 | 217.1 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

Sunday October 13, 1991 6:45 p.m.

LOCATION Q Queen

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 144.0 | |
| 2 | 33 | 144.3 | |
| 3 | 32 | 138.7 | |
| (4) | 31 | 135.7 | |
| 5 | 30 | 136.8 | |
| 6 | 29 | 141.0 | |
| 7 | 28 | 139.8 | |
| (8) | 27 | 141.0 | |
| 9 | 26 | 140.6 | |
| 10 | 25 | 143.6 | |
| 11 | 24 | 142.5 | |
| (12) | 23 | 144.3 | |
| 13 | 22 | 144.0 | |
| 14 | 21 | 141.7 | |
| 15 | 20 | 138.7 | |
| (16) | 19 | 141.0 | |
| 17 | 18 | 143.2 | |
| 18 | 17 | 141.7 | |
| 19 | 16 | 140.2 | |
| (20) | 15 | 142.1 | |
| 21 | 14 | 143.6 | |
| 22 | 13 | 143.2, | |
| 23 | 12 | 139.1 (139.1) | |
| (24) | 11 | 140.6 (140.6) | |
| 25 | 10 | 142.1 | |
| 26 | 9 | 142.5 | • |
| 27 | 8 | 138.3 | |
| (28) | 7 | 136.1 | |
| 29 | 6 | 136.8 | |
| 30 | 5 | 139.5 | |
| 31 | 4 | 138.7 | |
| | 3 | 138.3(1380) | |
| 33 | 2 | 135.0 | |
| 34 | 1 | 139.5 138.7 138.3(1380) 135.0 132.7 138.0 | |
| (35) | 0 | 138.0 | |

Unit 2 Baghouse Casing B Compartment B2

10/13/91 17:05 Doors Open Three Horn Operation: Two Horns in South Aisle and Horn near Door in North Aisle

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 136.8 | 138.4 |
| 2 | 33 | 139.5 | 188.8 |
| 3 | 32 | 138.3 | 164.4 |
| 4 | 31 | 138.7 | 172.2 |
| 5 | 30 | 138.7 | 172.2 |
| 6 | 29 | 139.8 | 195.4 |
| 7 | 28 | 137.6 | 151.7 |
| 8 | 27 | 138.0 | 158.9 |
| 9 | 26 | 139.1 | 180.3 |
| 10 | 25 | 139.1 | 180.3 |
| 11 | 24 | 135.7 | 121.9 |
| 12 | 23 | 133.5 | 94.6 |
| 13 | 22 | 135.0 | 112.5 |
| 14 | 21 | 137.6 | 151.7 |
| 15 | 20 | 137.2 | 144.9 |
| 16 | 19 | 138.3 | 164.4 |
| 17 | 18 | 138.0 | 158.9 |
| 18 | 17 | 138.0 | 158.9 |
| 19 | 16 | 136.5 | 133.7 |
| 20 | 15 | 138.3 | 164.4 |
| 21 | 14 | 138.0 | 158.9 |
| 22 | 13 | 135.7 | 121.9 |
| 23 | 12 | 131.6 | 76.0 |
| 24 | 11 | 135.7 | 121.9 |
| 25 | 10 | 138.0 | 158.9 |
| 26 | 9 | 139.5 | 188.8 |
| 27 | 8 | 136.8 | 138.4 |
| 28 | 7 | 135.0 | 112.5 |
| 29 | 6 | 134.6 | 107.4 |
| 30 | 5 | 137.6 | 151.7 |
| 31 | 4 | 136.8 | 138.4 |
| 32 | 3 | 138.3 | 164.4 |
| 33 | 2 | 139.1 | 180.3 |
| 34 | 1 | 137.2 | 144.9 |
| 35 | 0 | 139.1 | 180.3 |

| Average Integrated | 137.5 | 150.1 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

Sunday October 13, 1991 5:05 P.M.

Location R Randy

| Distance D.I. | | | Il-ta-sated Caused |
|----------------|-----------------|---|--------------------|
| Distance Below | Height Above | Integrated Sound | Integrated Sound |
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 136.8 | |
| 2 | 33 | 139.5 | |
| 3 | 32 | 138.3 | |
| (4) | 31 | 138.7 | |
|)5 | 30 | 138.7 | |
| 6 | 29 | 139.8 | |
| 7 | 28 | 137.6 | |
| 8 | 27 | 138.0 | |
| 9 | 26 | 139.1 | |
| 10 | 25 | 139.1 | |
| 11 | 24 | 135.7 | |
| (12) | 23 | 133.5 | |
| 13 | 22 | 135.Ø | |
| 14 | 21 | 137.6 | |
| 15 | 20 | 137.2 | |
| (16) | 19 | 138.3 | |
| 17 | 18 | 138.0 | |
| 18 | 17. | 138.0 | |
| 19 | 16 | 136.5 | |
| (20) | 15 | 138.3 | |
| 21 | 14 | 138.0 | |
| 22 | 13 | 135.7 | |
| 23 | 12 | 131.6 | |
| (24) | 11 | 135.7 | |
| 25 | 10 | 138.0 | |
| 26 | 9 | 139.5 | • |
| 27 | 8 | 136.8 | |
| 28) | 7 | 135.0 | |
| 29 | 6 | 134.6 | |
| 30 | 5 | 1276 | |
| | 4 | 136.8 | |
| 31 (32) | 3 | 138.3/138.9 | |
| 33 | 2 | 139.1 | |
| | 1 | 136.8 138.3(138.7 139.1 137.2 139.1 | |
| 34 (35) | 0 | 129.1 | |
| (35/ | 0. | 137.1 | |



| Unit 2 Baghouse | Casing B | Compartment B2 | |
|------------------------------|--------------------------------|-----------------------|--|
| 10/13/91 16:20 Location S | Doors Open Purge Air Fan On | Three Horn Operation: | Two Horns in South Aisle and Horn near Door in North Aisle |

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 132.7 | 86.3 |
| 2 | 33 | 137.2 | 144.9 |
| 3 | 32 | 136.1 | 127.7 |
| 4 | 31 | 135.3 | 116.4 |
| 5 | 30 | 132.1 | 80.5 |
| 6 | 29 | 129.7 | 61.1 |
| 7 | 28 | 130.1 | 64.0 |
| 8 | 27 | 132.7 | 86.3 |
| 9 | 26 | 135.7 | 121.9 |
| 10 | 25 | 136.5 | 133.7 |
| 11 | 24 | 133.1 | 90.4 |
| 12 | 23 | 132.3 | 82.4 |
| 13 | 22 | 132.0 | 79.6 |
| 14 | 21 | 133.5 | 94.6 |
| 15 | 20 | 131.6 | 76.0 |
| 16 | 19 | 132.3 | 82.4 |
| 17 | 18 | 136.1 | 127.7 |
| 18 | 17 | 138.3 | 164.4 |
| 19 | 16 | 136.8 | 138.4 |
| 20 | 15 | 136.5 | 133.7 |
| 21 | 14 | 131.6 | 76.0 |
| 22 | 13 | 132.0 | 79.6 |
| 23 | 12 | 135.0 | 112.5 |
| 24 | 11 | 138.3 | 164.4 |
| 25 | 10 | 139.1 | 180.3 |
| 26 | 9 | 137.6 | 151.7 |
| 27 | 8 | 132.7 | 86.3 |
| 28 | 7 | 132.0 | 79.6 |
| 29 | 6 | 136.1 | 127.7 |
| 30 | 5 | 139.1 | 180.3 |
| 31 | 4 | 138.3 | 164.4 |
| 32 | 3 | 138.7 | 172.2 |
| 33 | 2 | 137.2 | 144.9 |
| 34 | 1 | 135.0 | 112.5 |
| 35 | 0 | 137.2 | 144.9 |

| Average Integrated | 135.3 | 116.3 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL) DATA SHEET Smuly Oct. 13, 1991 4:20 P.M

Location S Safe

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 132.7 | |
| 2 | 33 | 137.2 | |
| 3 | 32 | 136.1 | |
| 4 | 31 | 135.3 | |
| 5 | 30 | 132.1 | |
| 6 | 29 | 129.7 | |
| 7 | 28 | 130.1 | |
| (8) | 27 | 132.7 | |
| 9 | 26 | 135.7 | |
| 10 | 25 | 13b.5 | |
| 11 | 24 | 1 33.1 | |
| (2) | 23 | 132.3 | |
| 13 | 22 | 132.0 | |
| 14 | 21 | 133.5 | |
| 15 | 20 | 131.6 | |
| (16) | 19 | 132.3 | |
| 17 | 18 | 136. | |
| 18 | 17 | 138.3 | |
| 19 | 16 | 136.8 | |
| 20 | 15 | 136.5 | |
| 21 | 14 | 131.6 | |
| 22 | 13 | 132.0 | |
| 23 | 12 | 135.0 | |
| (24) | 11 | 138.3 | |
| 25 | 10 | 139.1 | |
| 26 | 9 | 137.6 | * |
| 27 | 8 | 132.7 | |
| 28 | 7 | 132.0 | |
| 29 | 6 | 136.1 | |
| 30 | 5 | 1394 | |
| 31 | 4 | 138.3 | |
| (32) | 3 | 138.7(139.1 | |
| 33 | 2 | 137.2 | 1 |
| 34 | 1 | 135.0 | |
| (35) | 0 | 137.2 | |

Unit 2 Baghouse Casing B Compartment B2

9/29/91 17:00 Doors Open Three Horn Operation: Two Horns in South Aisle and Horn near Door in North Aisle

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 129.3 | 58.3 |
| 2 | 33 | 130.1 | 64.0 |
| 3 | 32 | 132.7 | 86.3 |
| 4 | 31 | 131.2 | 72.6 |
| 5 | 30 | 129.3 | 58.3 |
| 6 | 29 | 133.5 | 94.6 |
| 7 | 28 | 135.0 | 112.5 |
| 8 | 27 | 133.1 | 90.4 |
| 9 | 26 | 133.1 | 90.4 |
| 10 | 25 | 134.6 | 107.4 |
| 11 | 24 | 134.2 | 102.6 |
| 12 | 23 | 132.3 | 82.4 |
| 13 | 22 | 131.2 | 72.6 |
| 14 | 21 | 130.5 | 67.0 |
| 15 | 20 | 130.8 | 69.3 |
| 16 | 19 | 132.0 | 79.6 |
| 17 | 18 | 130.8 | 69.3 |
| 18 | 17 | 130.8 | 69.3 |
| 19 | 16 | 131.2 | 72.6 |
| 20 | 15 | 132.3 | 82.4 |
| 21 | 14 | 131.2 | 72.6 |
| 22 | 13 | 131.6 | 76.0 |
| 23 | 12 | 131.6 | 76.0 |
| 24 | 11 | 130.8 | 69.3 |
| 25 | 10 | 127.1 | 45.3 |
| 26 | 9 | 130.5 | 67.0 |
| 27 | 8 | 132.3 | 82.4 |
| 28 | 7 | 131.2 | 72.6 |
| 29 | 6 | 129.3 | 58.3 |
| 30 | 5 | 130.1 | 64.0 |
| 31 | 4 | 132.0 | 79.6 |
| 32 | 3 | 129.0 | 56.4 |
| 33 | 2 | 132.0 | 79.6 |
| 34 | 1 | 134.2 | 102.6 |
| 35 | 0 | 136.5 | 133.7 |

| Average Integrated | 131.8 | 78.2 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

DATA FORM BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL)

| • HORNS | BAGHOU | SE COMPAR | TMENT SOUND PI | RESSURE LI |
|----------------|-------------------------------|------------------------|----------------------------------|---------------------|
| \mathcal{D} | Sun 9/29/91 | Compartment: | B-2 | Measurement Pos |
| Doors open for | Horn Type | | Number PW | /MF |
| pura | Height Above Tubesheet, ft | Integrated SPL, dB* | Integrated Sound Pressure, Pa | SPL at PWMF, dB* |

| lorn Type | | | Number PV | | Sound Pressure |
|----------------|----------------------|------------------------|--|---------------------|----------------|
| Heigh Tubes | t Above sheet, ft | Integrated SPL, dB* | Integrated Sound Pressure, Pa | SPL at PWMF, dB* | at PWMF, Pa |
| ı | 34 | 129.3 | | | |
| 2 | 33 | 130.1 | | | |
| 3 4) 5 | 32 | 132.7 | and the second s | | |
| 4) | 31 | 131.2 | | | |
| 5 | 30 | 129.3 | | | |
| 6 | 29 | 1335 | | | |
| 2 | 28 | 135.0 | | | |
| 8) | 27 | 133.1 | | | |
| 9 | 26 | 133.1 | | | |
| סן | 25 | 134.6 | | | |
| Ц | 24 | 134.2 | | | |
| [2] | 23 | 132.3 | | | |
| 13 | 22 | 131.2 | | | |
| 4 | 21 | 130.5 | | | |
| <u> </u> | 20 | 130.8 | | | |
| (b) | | 132.0 | | | |
| 17 | 18 | 130.8 | | | |
| 18 | 17 | 130.8 | | | |
| 19 | 16 | 131.2 | | | |
| 20/_ | 15 | 131.2 | | | |
| 21 | 19 13 | 131.6 | | | |
| IL. | | 131.6 | | | |
| 23 | <u>12</u> 11 | 130.8 | | | |
| 9/_ | | 150.0 | | | |

Note This form may be reproduced *To convert to sound pressure $\rho = \rho_0 \log^{-1}(L_p/20)$

DATA FORM BAGHOUSE COMPARTMENT SOUND PRESSURE LEVEL (SPL)

3 Hours
Doors open
purge air fr

| Date ⁻ | 9/29/91 | Compartment. | B-2 | _ Measurement Positi | on: |
|------------------------|-------------------------------|------------------------|----------------------------------|----------------------|-------------------------------|
| Horn Ty | pe | | Number F | PWMF | Hz |
| | Height Above Tubesheet, ft | Integrated SPL, dB* | Integrated Sound Pressure, Pa | SPL at PWMF, dB* | Sound Pressure at PWMF, Pa |
| 25 24 27 28 | 10 | 127.1 | | | |
| 26 | 9 | 130.5 | | | |
| 27 | 8 | 132.3 | | | |
| 28) | 7 | 131.2 | | | |
| 29 | <u>6</u> | 129.3 | | | |
| 30 | | 136.1 | | | |
| 31 | 4 | 132.0 | | | |
| <u>32</u> <u>33</u> | 3 | 130.8 | (129.0) | | |
| 33 | 2 | 132.0 | | | |
| 34 | | 134.2 | | | |
| (35) |) 0 | 136.5 | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | · | | | |
| | | | | | |
| | | | l | | |

Note This form may be reproduced *To convert to sound pressure $p = p_0 \log^{-1}(L_p/20)$

| Unit 2 Baghouse | Casing B | Compartment B2 | |
|------------------------------|--------------------------------|-----------------------|--|
| 10/13/91 15:35 Location U | Doors Open Purge Air Fan On | Three Horn Operation: | Two Horns in South Aisle and Horn near Door in North Aisle |

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 136.1 | 127.7 |
| 2 | 33 | 135.7 | 121.9 |
| 3 | 32 | 130.1 | 64.0 |
| 4 | 31 | 130.8 | 69.3 |
| 5 | 30 | 135.7 | 121.9 |
| 6 | 29 | 139.1 | 180.3 |
| 7 | 28 | 136.5 | 133.7 |
| 8 | 27 | 135.0 | 112.5 |
| 9 | 26 | 133.8 | 98.0 |
| 10 | 25 | 137.2 | 144.9 |
| 11 | 24 | 135.3 | 116.4 |
| 12 | 23 | 133.1 | 90.4 |
| 13 | 22 | 132.0 | 79.6 |
| 14 | 21 | 137.6 | 151.7 |
| 15 | 20 | 137.2 | 144.9 |
| 16 | 19 | 138.3 | 164.4 |
| 17 | 18 | 137.2 | 144.9 |
| 18 | 17 | 133.1 | 90.4 |
| 19 | 16 | 132.0 | 79.6 |
| 20 | 15 | 135.0 | 112.5 |
| 21 | 14 | 134.6 | 107.4 |
| 22 | 13 | 132.3 | 82.4 |
| 23 | 12 | 130.5 | 67.0 |
| 24 | 11 | 136.1 | 127.7 |
| 25 | 10 | 138.7 | 172.2 |
| 26 | 9 | 138.7 | 172.2 |
| 27 | 8 | 134.6 | 107.4 |
| 28 | 7 | 133.8 | 98.0 |
| 29 | 6 | 139.5 | 188.8 |
| 30 | 5 | 141.3 | 232.3 |
| 31 | 4 | 138.3 | 164.4 |
| 32 | 3 | 138.0 | 158.9 |
| 33 | 2 | 139.1 | 180.3 |
| 34 | 1 | 138.3 | 164.4 |
| 35 | 0 | 140.2 | 204.7 |

| Average Integrated | 136.3 | 130.8 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

Sunday Oct. 13,1991 3:35 p.m.

Location. II Under

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 136.1 | |
| 2 | 33 | 135.7 | |
| 3 | 32 | 130.1 | |
| 4) | 31 | 130.8 | |
| 5 | 30 | 135.7 | |
| 6 | 29 | 139.1 | |
| 7_ | 28 | 136.5 | |
| (8) | 27 | 135.0 | |
| 9 | 26 | 133.8 | |
| 10 | 25 | 137.2 | |
| 11 | 24 | 135.3 | |
| (12) | 23 | 133.1 | |
| 13 | 22 | 132.0 | |
| 14 | 21 | 137.6 | |
| (15) | 20 | 137.2 | |
| (16) | 19 | 138.3 | |
| 17 | 18 | 138.3 137.2 | |
| 18 | 17 | 133.1 | |
| 19 | 16 | 132.0 | |
| (20) | 15 | 135.0 | |
| 21 | 14 | 134.6 | |
| 22 | 13 | 132.3 | ` |
| 23 | 12 | 130.5 | |
| 24 | 11 | 136.1 | |
| 25 | 10 | 138.7 | |
| 26 | 9 | 138.7 | • |
| 27 | 8 | 134.6 | |
| (28) | 7 | 133.8 | |
| 29 | 6 | 139.5 | |
| 30 | 5 | 141.2 | |
| 31 | 4 | 138.3 | |
| (32) | 3 | 139.0/138.7 | |
| 31 32 33 | 2 | 138.3 139.0(138.7) 139.1 138.3 140.2 | |
| 34_ | 1. | 139.3 | |
| (35) | 0, | 140.7 | |
| | | | |

| Unit 2 Baghouse | Casing B | Compartment B2 | |
|------------------------------|--------------------------------|-----------------------|--|
| 10/13/91 14:55 Location V | Doors Open Purge Air Fan On | Three Horn Operation: | Two Horns in South Aisle and Horn near Door in North Aisle |

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 138.7 | 172.2 |
| 2 | 33 | 135.3 | 116.4 |
| 3 | 32 | 132.3 | 82.4 |
| 4 | 31 | 134.2 | 102.6 |
| 5 | 30 | 138.3 | 164.4 |
| 6 | 29 | 139.8 | 195.4 |
| 7 | 28 | 138.0 | 158.9 |
| 8 | 27 | 137.2 | 144.9 |
| 9 | 26 | 133.8 | 98.0 |
| 10 | 25 | 136.5 | 133.7 |
| 11 | 24 | 137.2 | 144.9 |
| 12 | 23 | 138.0 | 158.9 |
| 13 | 22 | 138.0 | 158.9 |
| 14 | 21 | 136.1 | 127.7 |
| 15 | 20 | 133.8 | 98.0 |
| 16 | 19 | 138.7 | 172.2 |
| 17 | 18 | 138.3 | 164.4 |
| 18 | 17 | 136.8 | 138.4 |
| 19 | 16 | 133.1 | 90.4 |
| 20 | 15 | 137.2 | 144.9 |
| 21 | 14 | 141.0 | 224.4 |
| 22 | 13 | 140.6 | 214.3 |
| 23 | 12 | 136.1 | 127.7 |
| 24 | 11 | 136.1 | 127.7 |
| 25 | 10 | 140.6 | 214.3 |
| 26 | 9 | 142.5 | 266.7 |
| 27 | 8 | 139.1 | 180.3 |
| 28 | 7 | 137.2 | 144.9 |
| 29 | 6 | 137.6 | 151.7 |
| 30 | 5 | 138.3 | 164.4 |
| 31 | 4 | 136.8 | 138.4 |
| 32 | 3 | 135.7 | 121.9 |
| 33 | 2 | 136.8 | 138.4 |
| 34 | 1 | 138.0 | 158.9 |
| 35 | 0 | 141.3 | 232.3 |

| Average Integrated | 137.7 | 153.5 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

Sunday, October 13, 1991 2:55 p.m

Location V Yalve

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 138.7 | |
| 2 | 33 | 135.3 | |
| 3 | 32 | 132.3 | |
| 4 | 31 | 134.2 | |
| 5 | 30 | 138.3 | |
| 6 | 29 | 139.8 | |
| Z 8 | 28 | 138.0 | |
| 8 | 27 | 137.2 | |
| 9 | 26 | 133.8 | |
| 10 | 25 | 136.5 | |
| 11 | 24 | 137.2 | |
| (12) | 23 | 138.0 | |
| 13 | 22 | 138.0 | |
| 14 | 21 | 36. | |
| 15 | 20 | 133.8 | |
| (16) | 19 | 138.7 | |
| 17 | 18 | 138.3 | |
| 18 | 17 | 136.8 | |
| 19 | 16 | 133.1 | |
| (20) | 15 | 137.2 | |
| 21 | 14 | 141.0 | |
| 22 | 13 | 140.6 | |
| 23 | 12 | 136.1 | |
| 24) | 11 | /36.1 | |
| 25 | 10 | 140.6 | |
| 26 | 9 | 142.5 | • |
| 27 | 8 | 139.1 | |
| (28) | 7 | 137.2 | |
| 29 | 6 | 37.6 | |
| 30 | 5 | 136.3 | |
| 31 | 4 | 136.8 | |
| (32) | 3 | 136.8/135.7) | |
| 33 | 2 | 136.8 | |
| 34 (35) | 1 | 136.8 (36.8/135.7) 136.8 138.0 141.3 | |
| (35) | 0 | 141.3 | |

| Unit 2 Baghouse | Casing B | Compartment B2 | | | | |
|------------------------------|--------------------------------|-----------------------|--|--|--|--|
| 10/13/91 10:05 Location W | Doors Open Purge Air Fan On | Three Horn Operation: | Two Horns in South Aisle and Horn near Door in North Aisle | | | |

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 138.7 | 172.2 |
| 2 | 33 | 129.0 | 56.4 |
| 3 | 32 | 130.8 | 69.3 |
| 4 | 31 | 136.8 | 138.4 |
| 5 | 30 | 138.7 | 172.2 |
| 6 | 29 | 138.7 | 172.2 |
| 7 | 28 | 135.7 | 121.9 |
| 8 | 27 | 132.7 | 86.3 |
| 9 | 26 | 135.7 | 121.9 |
| 10 | 25 | 139.1 | 180.3 |
| 11 | 24 | 138.0 | 158.9 |
| 12 | 23 | 137.6 | 151.7 |
| 13 | 22 | 133.8 | 98.0 |
| 14 | 21 | 129.3 | 58.3 |
| 15 | 20 | 132.0 | 79.6 |
| 16 | 19 | 135.7 | 121.9 |
| 17 | 18 | 137.2 | 144.9 |
| 18 | 17 | 133.8 | 98.0 |
| 19 | 16 | 134.2 | 102.6 |
| 20 | 15 | 138.3 | 164.4 |
| 21 | 14 | 139.8 | 195.4 |
| 22 | 13 | 139.1 | 180.3 |
| 23 | 12 | 133.1 | 90.4 |
| 24 | 11 | 129.0 | 56.4 |
| 25 | 10 | 137.6 | 151.7 |
| 26 | 9 | 140.2 | 204.7 |
| 27 | 8 | 137.6 | 151.7 |
| 28 | 7 | 134.6 | 107.4 |
| 29 | 6 | 134.6 | 107.4 |
| 30 | 5 | 138.7 | 172.2 |
| 31 | 4 | 139.1 | 180.3 |
| 32 | 3 | 139.5 | 188.8 |
| 33 | 2 | 136.1 | 127.7 |
| 34 | 1 | 133.8 | 98.0 |
| 35 | 0 | 137.2 | 144.9 |

| Average Integrated | 136.4 | 132.2 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

Sunday October 13,1991 10:05 A.M LOCATION W Watermelon

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 38.7 | |
| 2 | 33 | 129.0 | |
| 3 | 32 | 130.8 | |
| 4> | 31 | 136.8 | |
| 5 | 30 | 138.7 | |
| 6 | 29 | 138.7 | |
| 7 | 28 | 35.7 | |
| 8 | 27 | 132.7 | |
| 9 | 26 | 135.7 | |
| 10 | 25 | 139,1 | |
| 11 | 24 | 138.0 | |
| (2) | 23 | 137.6 | |
| 13 | 22 | 133.8 | |
| 14 | 21 | 129.3 | |
| 15 | 20 | 132.0 | |
| (16) | 19 | 135.7 | |
| 17 | 18 | 137.2 | |
| 18 | 17 | 133.8 | |
| 19 | 16 | 134.2 | |
| 20 | 15 | 138.3 | |
| 21 | 14 | 139.8 | |
| 22 | 13 | 139.1 | |
| 23 | 12 | 133.1 | |
| (24) | 11 | 129.0 | |
| 25 | 10 | 137.6 | |
| 26 | 9 | 140.2 | • |
| 27 | 8 | 137.6 | |
| (28) | 7 | 134.6 | |
| 29 | 6 | 134.6 | |
| 30 | 5 | 136.7 | |
| 31 | 4 | 139.1 | |
| (32) | 3 2 | 139.8(139.5) | |
| 33 | | 136.1 | |
| 34 | 1 | 133.8 | |
| (35) | 0 | | |
| | | | |

| Unit 2 Baghouse Casing B | | Compartment B2 | - |
|------------------------------|--------------------------------|-----------------------|--|
| 10/12/91 15:45 Location X | Doors Open Purge Air Fan On | Three Horn Operation: | Two Horns in South Aisle and Horn near Door in North Aisle |

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 135.7 | 121.9 |
| 2 | 33 | 139.5 | 188.8 |
| 3 | 32 | 136.8 | 138.4 |
| 4 | 31 | 136.8 | 138.4 |
| 5 | 30 | 136.1 | 127.7 |
| 6 | 29 | 134.2 | 102.6 |
| 7 | 28 | 134.6 | 107.4 |
| 8 | 27 | 135.7 | 121.9 |
| 9 | 26 | 137.6 | 151.7 |
| 10 | 25 | 138.7 | 172.2 |
| 11 | 24 | 138.3 | 164.4 |
| 12 | 23 | 139.8 | 195.4 |
| 13 | 22 | 139.8 | 195.4 |
| 14 | 21 | 137.6 | 151.7 |
| 15 | 20 | 135.3 | 116.4 |
| 16 | 19 | 136.8 | 138.4 |
| 17 | 18 | 139.8 | 195.4 |
| 18 | 17 | 141.3 | 232.3 |
| 19 | 16 | 139.1 | 180.3 |
| 20 | 15 | 135.0 | 112.5 |
| 21 | 14 | 139.1 | 180.3 |
| 22 | 13 | 136.1 | 127.7 |
| 23 | 12 | 137.2 | 144.9 |
| 24 | 11 | 141.0 | 224.4 |
| 25 | 10 | 143.2 | 289.1 |
| 26 | 9 | 144.0 | 317.0 |
| 27 | 8 | 139.8 | 195.4 |
| 28 | 7 | 139.1 | 180.3 |
| 29 | 6 | 141.7 | 243.2 |
| 30 | 5 | 143.2 | 289.1 |
| 31 | 4 | 140.2 | 204.7 |
| 32 | 3 | 141.0 | 224.4 |
| 33 | 2 | 139.1 | 180.3 |
| 34 | 1 | 139.5 | 188.8 |
| 35 | 0 | 142.5 | 266.7 |

| Average Integrated | 139.1 | 180.3 |
|--------------------|----------|---------|
| Sound Pressure | Decibals | Pascals |

Saturday October 12,1991 3:45

Location X

| Distance Below | Height Above | Integrated Sound | Integrated Sound |
|----------------|-----------------|--------------------|------------------|
| Hook, feet | Tubesheet, feet | Pressure Level, dB | Pressure, Pa |
| 1 | 34 | 135.7 | |
| 2 | 33 | 139.5 | |
| | 32 | 136.8 | |
| 3 (4) | 31 | 136.8 | |
| 5 | 30 | 136.1 | |
| 6 | 29 | 134.2 | |
| 7 | 28 | 134.6 | |
| 7 | 27 | 135.7 | |
| 9 | 26 | 137.6 | |
| 10 | 25 | 38.7 | |
| 11 | 24 | 138.3 | |
| (12) | 23 | 139.8 | |
| 13 | 22 | 139.8 | |
| 14 | 21 | 137.6 | |
| 15 | 20 | 135.3 | |
| (16) | 19 | 136.8 | |
| 17 | 18 | 139.8 | |
| 18 | 17 | 141.3 | |
| 19 | 16 | 139.1 | |
| <u>(20)</u> | 15 | 135.0 | |
| 21 | 14 | 139.1 | |
| 22 | 13 | 136.1 | |
| 23 | 12 | 137.2 | |
| (24) | 11 | 141.0 | |
| 25 | 10 | 143.2 | |
| 26 | 9 | 144.0 | 4 |
| 27 | 8 | 139.8 | |
| 28) | 7 | 139.1 | |
| 29 | 6 | 141.7 | |
| 30 | 5 | 143.2 | |
| 31 | 4 | 140.2 | |
| (32) | 3 | 141.7 (141.0) | |
| 33 | 2 | 139.1 | |
| 34 | 1 | 139.5 | |
| (35) | 0 | 142.5 | |

Appendix G

Test Results and Calculations



| PROJECT NO. | NO NO. 91- | 97693-00 PAGE | OF | 3_ |
|--------------------|------------|---------------|----|------|
| ORIGINATED BY JEFF | PAYNE DATE | CHECKED BY | | DATE |
| 5000 | Hica Tank | Octoble | | |

DESCRIPTION SONIC MOIN

differential pressure can Compartment or tubesheet be calculated as follows:

$$\Delta P = \frac{Q * 5}{A}$$

Where ΔP - tubesheet or compartment differential pressure, in 420

pressure, in HZU

Q - volumetric flow rate, ft3/min

S - fabric drag, in HzO/ft/min

A - surface area of filter cloth material, ft²

Q/A - gas to cloth ratio which is a Key design

parameter for fabric filters, ft/min.

Assign subscripts for before and after sonic horn assisted cleaning as follows:

1 = before sonic horns 2 = after sonic horns

$$\Delta P_1 = \frac{Q_1 * S_1}{A}$$

$$\Delta P_2 = \frac{Q_2 * S_2}{A}$$

The surface area of filter cloth material, A, is a constant and does not change because of sonic horn assisted cleaning,

Dividing Equation 2 by Equation 3 and solving for Sz yields the following

$$S_2 = \frac{\Delta P_2 \left(Q_1 * S_1\right)}{\Delta P_1 * Q_2}$$
 (Equation 4)

Solving for Q1 in Equation 2 yields

$$Q_1 = \frac{\Delta P_1 * A}{S_1}$$



DESCRIPTION Sonic Horn Test Calculations

What we really want to know is the new differential pressure for the situation of normal volumetric flow rate with the reduced dara tabric drag which should result from sonic assisted cleaning of the bags. The equation of interest is then

$$\Delta P_{\text{new}} = \frac{Q_1 * S_2}{A}$$
 (Equation 6)

where

Q, - is the normal volumetric flow rate for equal drag distribution that was measured before sonic horn assisted cleaning, ft3/min

52 tabric drag after sonic assisted cleaning.

Substitute Equation 4 for S_z and Equation 5 for Q_1 to get the following

$$\Delta P_{\text{new}} = \left(\frac{\Delta P_1 * A}{5!} * \frac{\Delta P_2(Q_1 * S_1)}{\Delta P_1 * Q_2}\right) = \Delta P_2 * \left(\frac{Q_1}{Q_2}\right)$$
(Equation 7)

Equation 7 will be used to calculate the new differential Pressure for a compartment operating in a baghouse where all compartments have sonic horns installed in them to assist with cleaning.



| PROJECT NO. | | wo | NO. 91- | 97693-00 | PAGE | : <u>3</u> | OF | 3 | |
|---------------|--------|--------|---------|-------------|------|------------|----|------|--|
| ORIGINATED BY | JEFF | PAYNE | DATE | CHECKED | BY | | | DATE | |
| | Social | · Hara | Toct | Calculation | . < | | | | |

The sonic horns that were installed in Unit Z's compartment B2 were BHA Group, Inc. 's AH-25 horns.

The sonic horns were first used during a cleaning Cycle on April 10,1991 at 11:09:20 thru

As shown on the attached graphs and computer printouts, average compartment BZ tubesheet ΔP , as recorded for IBFM's 6,7,8,9 and 10, during the period from 9:07 to 11:00 is conservatively approximately 6.40 intz0. $\Delta P_1 \cong 6.40$ intz0. To be event more conservative and try to get the differential pressure just after cleaning I will use $\Delta P_1 \cong 6.0$ intz0.

As shown on the attached graphs and computer printouts, average compartment B2 tubesheet DP, as recorded for IBFM 6, during sonic horn assisted cleaning and just after cleaning is conservatively 5.25 inH2O. DP2 = 5.25 thH2O.

Gas to Cloth ratios, (G/C, ft/min), will be used to calculate the ratio of volumetric flow rates.

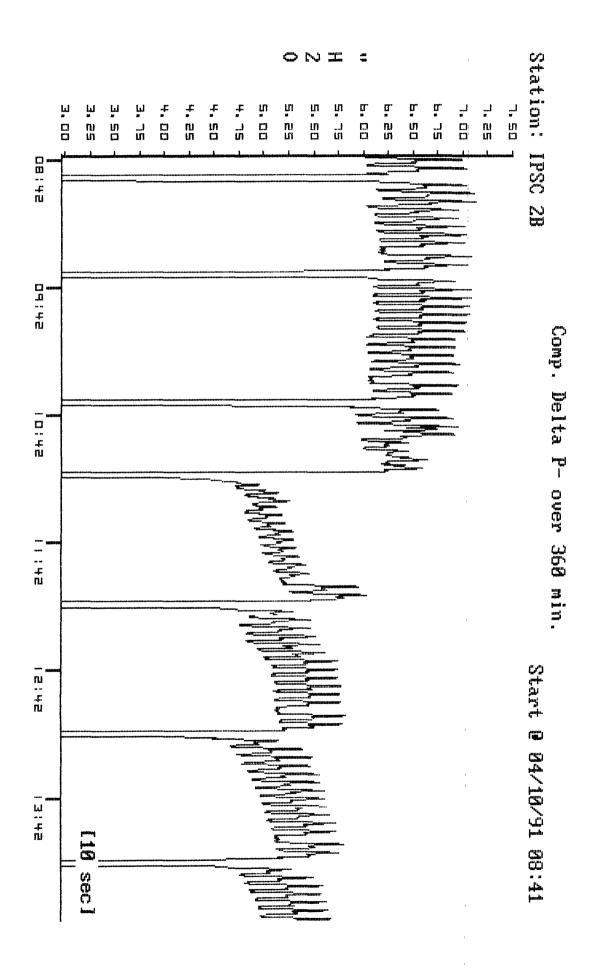
GIC (f/min) before homs is approximately 1.80 f/min. Q1/A = 1.80 ft/min.

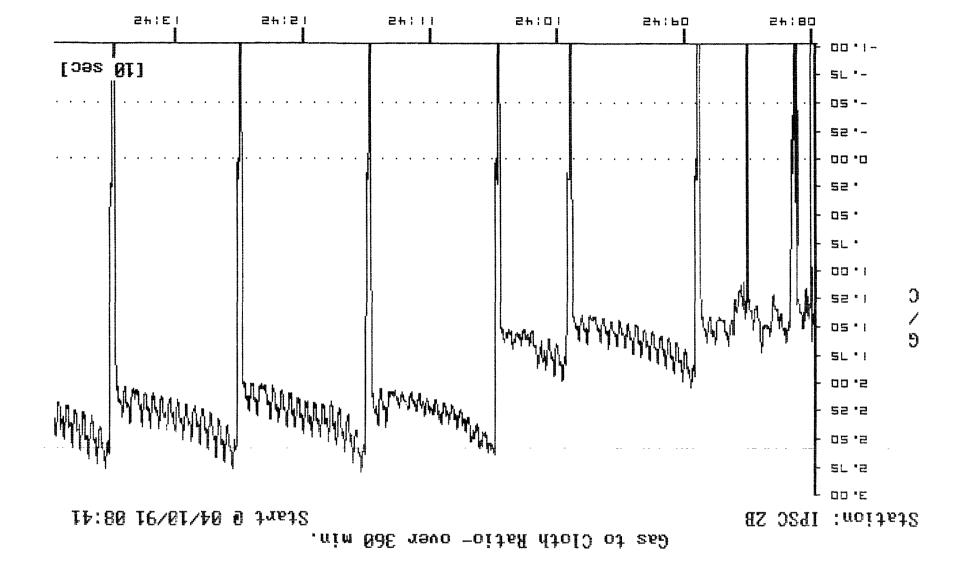
G/C (f/min) after horns is approximately 2.55 ft/min. $Q_2/A = 2.55$ ft/min.

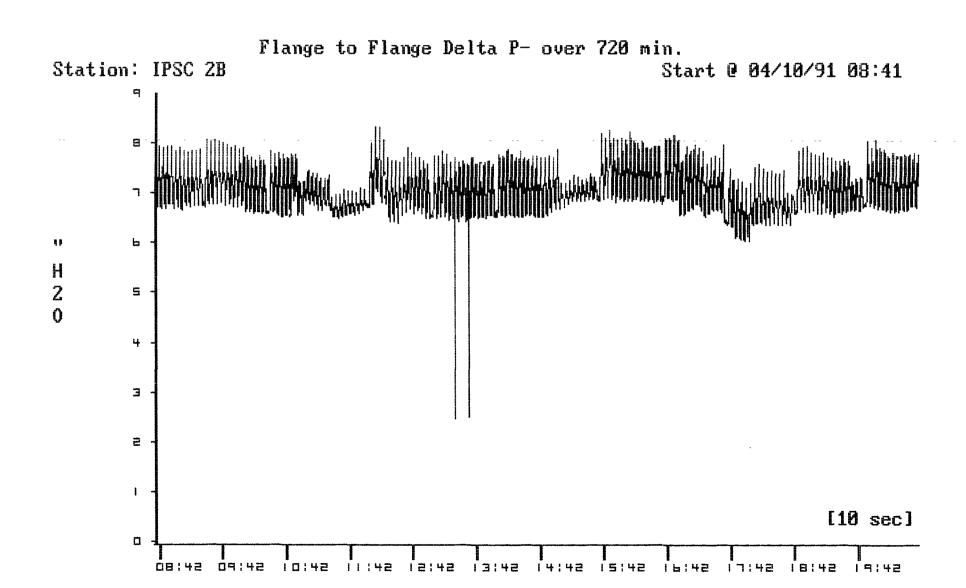
Substituting these values into Equation 7 gives the following:

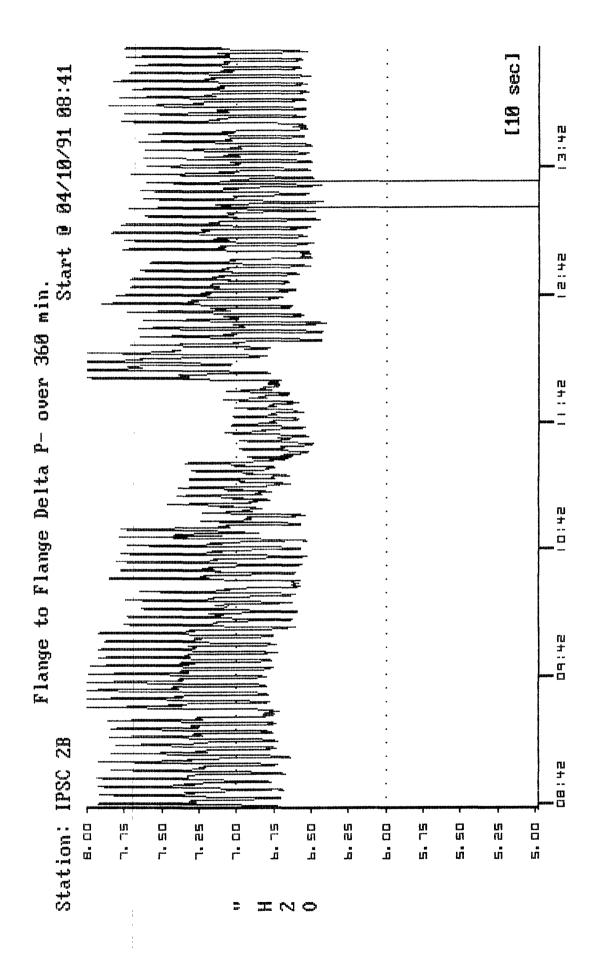
$$\Delta P_{\text{new}} = 5.25 \text{ in H}_20 * \left(\frac{1.80 \text{ ft/min}}{2.55 \text{ ft/min}}\right) = 3.71 \text{ in H}_20$$

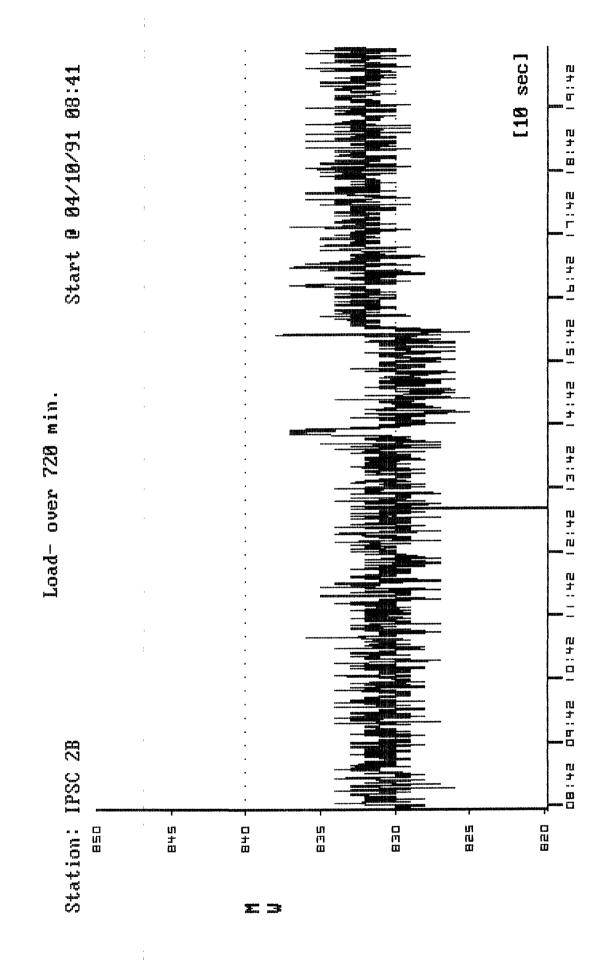
 $\Delta P_1 - \Delta P_{new} = 6.0 \text{ in H}_20 - 3.7 \text{ in H}_20 = 2.3 \text{ in H}_20$ An overall reduction of 2.3 in H $_20$ in differential pressure is calculated.

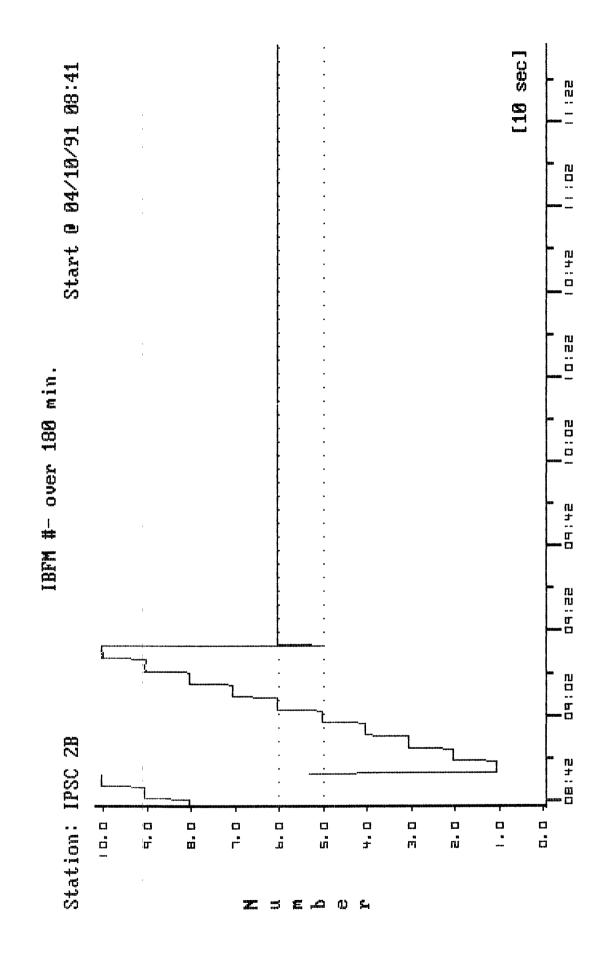


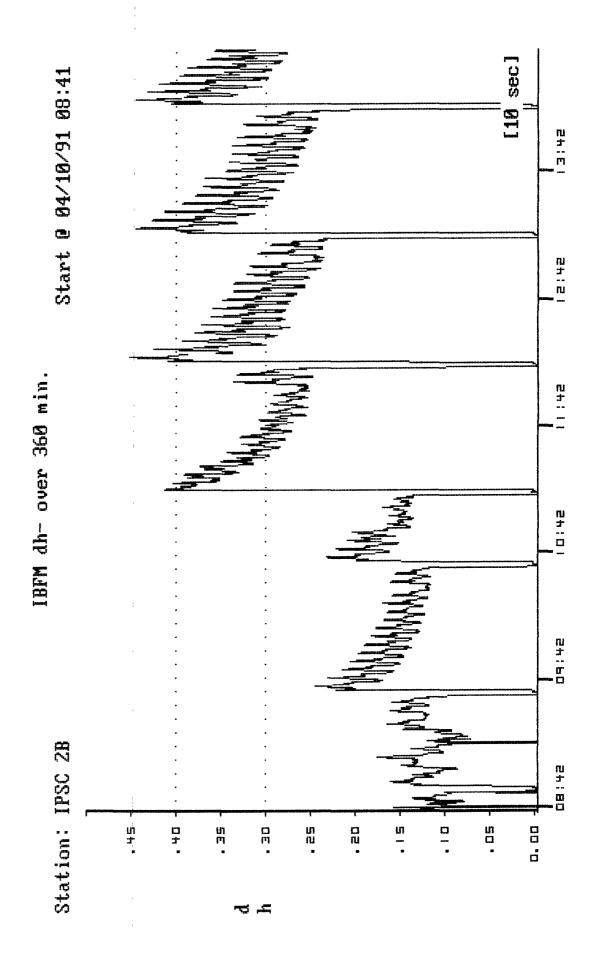


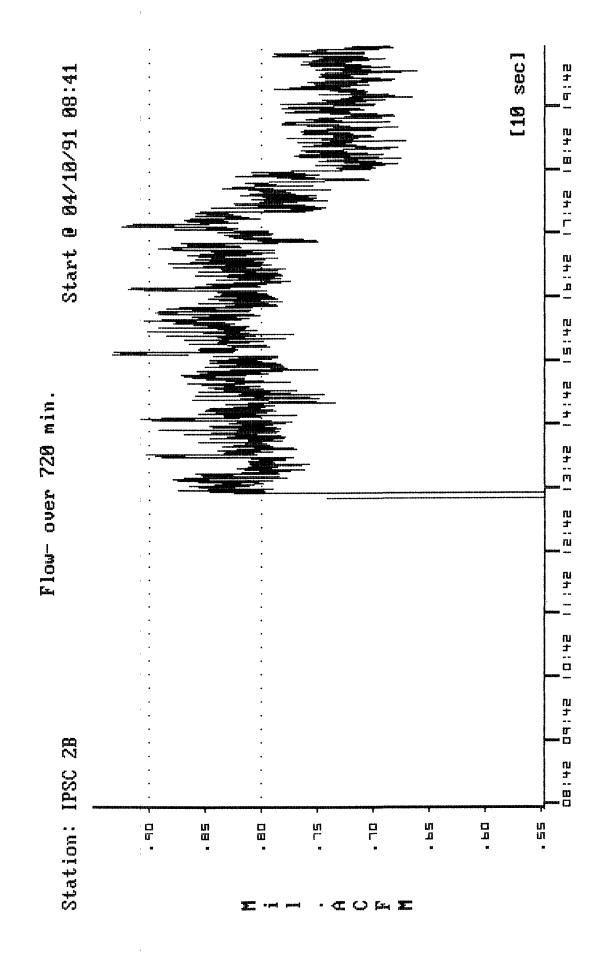












| Station: | | | 1 | | | |
|-----------|----------|---------------------|-----------------|------------------|--------------------|--------------------|
| ate | Time | F1-F1 dP | | Drag | Comp. dP | F1-F1 di |
| | | Complemp In Temp | Opacity Flow | Load Sys. G/C | IBFM # Sys.Drag | IBFM dh SonicAi |
| 4/10/1991 | 10:41:20 | 7.11 | 1.84 | 3.35 | 6.38 | 7.11 |
| , | | 290.4 | 1.59 | 829 | 6 | 0.200 |
| | | 239.7 | -0.4000 | -0.64 | -11.03 | -30.0 |
| | 10:41:30 | 7.12 | (1.81) | 3.42 | 6.38 | 7.12 |
| | | 290.5 | 1.57 | 829 | 6 | 0.192 |
| | | 239.9 | -0.4120 | -0.66 | -10.72 | -30.0 |
| | 10:41:40 | 7.16 | (1.84) | 3.38 | 6.41 | 7.16 |
| | | 290.5 | 1.40 | 830 | 6 | 0.199 |
| | 10-11-50 | 239.4 | -0.3990 | -0.64 | -11.13 | -30.0 |
| | 10:41:50 | 6.99 | (1.75) | 3.42 | 6.17 | 6.99 |
| | | 290.5 | 1.40 | 830 | 6 | 0.180 |
| | 10:42:00 | 239.8 | -0.4030 | -0.65 | -10.77 | -30.0 |
| | 10:42:00 | 6.64 290.5 | 1.70 | 3.42 | 5.98 6 | 6.64 0.170 |
| | | 240.0 | -0.3990 | 829 | -10.33 | -30.0 |
| | 10:42:10 | 6.57 | | -0.64 3.45 | 5.93 | 6.57 |
| | 10:75:10 | 290.6 | 1.67 | 829 | J. 73 | 0. 164 |
| | | 240.0 | -0.4020 | -0.65 | -10.14 | -30.0 |
| | 10:42:20 | 6.60 | (1.67) | 3.51 | 6.01 | 6.60 |
| | 10112120 | 290.6 | 1.41 | 830 | 6 | 0.163 |
| | | 239.8 | -0.3980 | -0.64 | -10.29 | -30.0 |
| _ | 10:42:30 | 6.57 | 1.69 | 3.42 | 5.95 | 6.57 |
| | | 290.6 | 1.39 | 830 | 6 | 0.168 |
| | | 239.7 | -0.4060 | -0.65 | -10.04 | -30.0 |
| | 10:42:40 | 6.58 | (1.66) | 3.49 | 5.96 | 6.58 |
| | | 290.6 | 1.31 | 830 | 6 | 0.162 |
| | | 240.0 | -0.4020 | -0.65 | -10.16 | -30.0 |
| | 10:42:50 | 6.57 | (1.67) | 3.49 | 5.98 | 6.57 |
| | | 290.7 | 1.30 | 831 | 6 | 0. 163 |
| | | 239.4 | -0.3980 | -0.64 | -10.24 | -30.0 |
| | 10:43:00 | 6.62 | (1.68) | 3.48 | 6.00 | 6.62 |
| | | 290.6 | 1.31 | 831 | 6 | 0.165 |
| | | 239.8 | -0.4040 | -0.65 | -10.16 | -30.0 |
| | 10:43:10 | 6.92 | (1.77) | 3.48 | 6.35 | 6.92 |
| | | 290.7 | 1.30 | 831 | 6 | 0.184 |
| | | 239.8 | -0.4000 | -0.64 | -10.74 | -30.0 |
| | 10:43:20 | 7.06 | (1.79) | 3.46 | 6.37 | 7.06 |
| | | 290.8 | 1.31 | 831 | 6 | 0. 188 |
| | | 239.7 | -0.4060 | -0.65 | -10.79 | -30.0 |
| | 10:43:30 | 7.16 | (1.81) | 3.49 | 6.51 | 7.16 |
| | | 290.9 | 1.29 | 830 | 6 | 0.192 |
| | | 240.3 | -0.4030 | -0.65 | -11.02 | -30.0 |
| | 10:43:40 | 7.55 | (1.92) | 3.44 | 6.83 | 7.55 |
| | | 290.7 | 1.21 | 831 | 6 | 0.217 |
| | | 239.7 | -0.4000 | -0.64 | -11.71 | -30.0 |
| | 10:43:50 | 7.72 | (1.94) | 3.44 | 6.91 | 7.72 |
| | | 291.0 | 1.20 | 830 | 6 | 0.222 |
| | 4.54 | 239.9 | -0.4040 | -0.65 | -11.85 | -30.0 |
| | 10:44:00 | 7.73 | (1.90) | 3.52 | 6.89 | 7.73 |
| | | 290.9 | 1.20 | 830 | 6 | 0.212 |
| | | 239.9 | -0.4130 | -0.67 | -11.61 | -30.0 |
| | | | | | | |

| _Station: | IPSC 2B | | | | | |
|-----------|----------|---------------|-------------------|----------------|-----------------|----------------|
| ate | Time | F1-F1 dP | | Drag | Comp. dP | |
| | | СомрТемр | • | | IBFM_# | IBFM dh |
| | | In Temp | Flow | Sys. G/C | Sys.Drag | SonicAir |
| 4/10/1991 | 10:44:10 | 7.63 | 1.89 | 3.48 | 6.78 | 7.63 |
| | | 291.1 | 1.21 | 831 | 6 | 0.210 |
| | | 240.1 | -0.4050 | -0.65 | -11.69 | -30.0 |
| | 10:44:20 | 7.23 | (1.79) | 3.51 | 6.48 | 7.23 |
| | | 291.2 | 1.21 | 830 | 6 | 0.189 |
| | | 239.7 | -0.3990 | -0.64 | -11.24 | -30.0 |
| | 10:44:30 | 7.12 | 1.77 | 3.52 | 6.42 | 7.12 |
| | | 291.1 | 1.21 | 829 | 6 | 0.184 |
| | | 239.8 | -0.4050 | -0.65 | -10.91 | -30.0 |
| | 10:44:40 | 7.10 | 1.78 | 3.51 | 6.42 | 7.10 |
| | | 291.1 | 1.30 | 829 | 6 | 0.185 |
| | | 240.1 | -0.4080 | -0.66 | -10.80 | -30.0 |
| | 10:44:50 | 7.13 | 1.79 | 3.48 | 6.43 | 7.13 |
| | | 291.1 | 1.30 | 829 | 6 | 0.189 |
| | | 239.9 | -0.4070 | -0.66 | -10.87 | -30.0 |
| | 10:45:00 | 7.15 | 1.78 | 3.52 | 6.44 | 7.15 |
| | | 291.0 | 1.29 | 831 | 6 | 0.185 |
| | 10 (= 10 | 240.0 | -0.4070 | -0.66 | -10.90 | -30.0 |
| | 10:45:10 | 7.14 | 1.76 | 3.56 | 6.45 | 7.14 |
| | | 291.0 | 1.30 | 832 | 6 | 0.182 |
| | 40 / | 239.9 | -0.4050 | -0.65 | -10.94 | -30.0 |
| | 10:45:20 | 7.15 | 1.79 | 3.50 | 6.44 | 7.15 |
| • | | 291.1 | 1.30 | 833 | 6 | 0.188 |
| | 40 (5 70 | 240.2 | -0.4050 | -0.65 | -10.95 | -30.0 |
| | 10:45:30 | 7.18 | 1.78 | 3.54 | 6.47 | 7.18 |
| | | 291.1 | 1.30 | 834 | 6 | 0.185 |
| | 10.45.40 | 240.1 | -0.4010 | -0.65 | -11.11 | -30.0 |
| | 10:45:40 | 7.08 | 1.76 | 3.52 | 6.37 | 7.08 |
| | | 291.2 | 1.29 | 834 | 6 | 0.181 |
| | 10:45:50 | 240.5 | -0.4070 | -0.66 | -1 0. 79 | -30.0 |
| | 16:47:76 | 6.69 291.1 | 1.68 | 3.61 | 5.99 | 6.69 |
| | | | 1.30 | 831 | 6 | 0. 154 |
| | 10:46:00 | 239.8 | -0.4030 | -0.65 | -10.29 | -30.0 |
| | 10:40:00 | 3.48 | 0.00 | 0.00 | 1.79 | 3.48 |
| | | 6.4 6.1 | 7.13 | 291 | 1 -0.41 | 829.000 |
| | 10:46:10 | | 0.1890 | 239.90 | | -0.7 |
| | 10:40:10 | 6.55 | 1.61 | 3.59 | 5.95 | 6.55 |
| | | 291.1 | 1.29 | 829 | 6 | 0.153 |
| | 10:46:20 | 239.9 6.53 | -0.4030 | -0.65 3.60 | -10.09 | -30.0 |
| | 10:40:00 | 291.0 | 1.61 | | 5.97 | 6.53 |
| | | | 1.30 | 829 | 6 | 0.153 |
| | 10:46:30 | 240.1 6.57 | -0.4040 | - 0. 65 | -10.02 | -30.0 |
| | 10:40:30 | | 1.61 | 3.61 | 5.99 | 6.57 |
| | | 291.1 | 1.29 | 830 | 6 | 0. 153 |
| | 10:46:40 | 240.2 6.57 | -0.4070 | -0.66 3.56 | -10.02 5.95 | -30.0 6.57 |
| | 10140146 | 6.57 291.2 | 1.63 | 3.56 | 5.95 6 | 0.156 |
| | | 240.1 | 1.21 -0.3990 | 830 -0 44 | -10.21 | -30.0 |
| | 10:46:50 | 6.56 | | -0.64 | -10.21 5.99 | |
| | MC:04:01 | 8.36 291.2 | 1.61 ₁ | 3.63 | a. 77 6 | 6.56 0.152 |
| | | 240.6 | 1.21 -0.4010 | 830 -0.65 | -10.15 | 0.152 -30.0 |
| | | LTU. O | O. 4010 | . 6. 67 | TW LU | J9. 9 |
| | | | | | | |

| Station: Pate | IPSC 2B Time | F1-F1 dP CompTemp In Temp | Act.G/C Opacity Flow | Drag Load Sys. G/C | Comp. dP IBFM # Sys.Drag | Fl-Fl dP IBFM dh SonicAir |
|------------------|-----------------|---------------------------------|----------------------------|--------------------------|--------------------------------|---------------------------------|
| | | · | | | | |
| 4/10/1991 | 10:47:00 | 6.78 | 1.70 | 3.58 | 6.27 | 6.78 |
| | | 291.2 | 1.20 | 831 | 6 | 0.170 |
| | 10-47-10 | 240.3 | -0.4040 | -0.65 | -10.41 | -30.0 |
| | 10:47:10 | 7.02 291.2 | 1.72 | 3.64 | 6.43 | 7.02 |
| | | 239.9 | 1.20 -0.4020 | 831 | 6 -10.83 | 0.174 -30.0 |
| | 10:47:20 | 7.08 | 1.75 | -0.65 3.59 | 6.44 | -30.0 7.08 |
| | 10.77100 | 291.2 | 1.73 | 830 | 6 | Ø. 179 |
| | | 240.3 | -0.4060 | -0.65 | -10.82 | -30.0 |
| | 10:47:30 | 7.35 | 1.84 | 3.55 | 6.74 | 7.35 |
| | 1017/100 | 291.2 | 1.17 | 830 | 6 | 0.199 |
| | | 239.9 | -0.4020 | -0.65 | -11.34 | -30.0 |
| | 10:47:40 | 7.69 | 1.89 | 3.56 | 6.92 | 7.69 |
| | 10111110 | 291.3 | 1.00 | 830 | 6 | 0.209 |
| | | 240.0 | -0.4020 | -0.65 | -11.87 | -30.0 |
| | 10:47:50 | 7.79 | 1.88 | 3.59 | 6.96 | 7.79 |
| | | 291.3 | 0.99 | 830 | 6 | 0.208 |
| | | 240.1 | -0.4030 | -0.65 | -11.99 | -30.0 |
| | 10:48:00 | 7.74 | 1.89 | 3.55 | 6.91 | 7.74 |
| | | 291.4 | 1.00 | 831 | 6 | 0.209 |
| | | 239.8 | -0.4090 | -0.66 | -11.74 | -30.0 |
| | 10:48:10 | 7.40 | 1.78 | 3.61 | 6.62 | 7.40 |
| | | 291.4 | 1.00 | 831 | 6 | 0. 186 |
| | | 240.4 | -0.4110 | -0.66 | -11.17 | -30.0 |
| | 10:48:20 | 7.11 | 1.71 | 3.66 | 6.43 | 7.11 |
| | | 291.4 | 1.00 | 830 | 6 | 0. 172 |
| | | 240.3 | -0.4010 | -0.65 | -11.00 | -30.0 |
| | 10:48:30 | 7.10 | 1.73 | 3.65 | 6.48 | 7.10 |
| | | 291.5 | 0.98 | 830 | 6 | 0.175 |
| | | 240.4 | -0.4020 | -0.65 | -10.96 | -30.0 |
| | 10:48:40 | 7.24 | 1.77 | 3.66 | 6.66 | 7.24 |
| | | 291.4 | 0.81 | 830 | 6 | 0.183 |
| | 10.10.50 | 240.1 | -0.4070 | -0.66 | -11.04 | -30.0 |
| | 10:48:50 | 7.42 | 1.80 | 3.63 | 6.72 | 7.42 |
| | | 291.4 | 0.81 | 830 | 6 | 0.190 |
| | 10:49:00 | 240.2 7.40 | -0.3990 | -0.64 | -11.54 | -30.0 |
| | 10:47:00 | 7.40 291.5 | 1.80 0.81 | 3.62 829 | 6.70 6 | 7.40 0.190 |
| | | 240.3 | -0.3990 | -0.64 | -11.51 | -30.0 |
| | 10:49:10 | 7.38 | 1.81 | -0.64 3.61 | 6.74 | 7.38 |
| | 10.45.10 | 291.4 | 0.81 | 830 | 6 | 0.193 |
| | | 240.1 | -0.4000 | -0.64 | -11.45 | -30.0 |
| | 10:49:20 | 7.35 | 1.80 | 3.61 | 6.71 | 7.35 |
| | | 291.5 | 0.80 | 830 | 6 | 0.191 |
| | | 240.2 | -0.4010 | -0.65 | -11.37 | -30.0 |
| | 10:49:30 | 7.35 | 1.79 | 3.63 | 6.70 | 7.35 |
| | | 291.5 | 0.81 | 830 | 6 | 0.189 |
| | | 240.1 | -0.4030 | -0.65 | -11.31 | -30.0 |
| | 10:49:40 | 7.09 | 1.68 | 3.70 | 6.38 | 7.09 |
| | | | | | | |
| | | 291.5 | 0.80 | 831 | 6 | 0.166 |

| 4/10/1991 | Time 10:49:50 10:50:00 | F1-F1 dP CompTemp In Temp 6.86 291.6 240.2 6.85 | | Drag Load Sys. G/C 3.72 830 | 6.22 | F1-F1 dF IBFM dh SonicAir 6.86 |
|-------------|---|---|----------------|---|--------|---|
| 4/10/1991 | 10:50:00 | 291.6 24 0. 2 | 0.80 | | | |
| 1, 10, 13,1 | 10:50:00 | 291.6 24 0. 2 | 0.80 | | | |
| | | 240.2 | | | 6 | 0.156 |
| | | | (C) € TEC / E3 | -0.66 | -10.46 | -30.0 |
| | | 0.00 | 1.68 | 3.68 | 6.34 | 6.85 |
| | | 291.4 | 0.80 | 830 | 6 | Ø. 165 |
| | | 240.2 | -0.4030 | -0.65 | -10.55 | -30.0 |
| | 10:50:10 | 7.04 | 1.71 | 3.67 | 6.44 | 7.04 |
| | 10.00.10 | 291.4 | 0.81 | 829 | 6 | 0.171 |
| | | 240.8 | -0.4020 | -0.65 | -10.86 | -30.0 |
| | 10:50:20 | 7.10 | 1.71 | 3.67 | 6.46 | 7.10 |
| | 10.00.00 | 291.5 | 0.80 | 829 | 6 | 0.172 |
| | | 240.6 | -0.4020 | -0.65 | -10.96 | -30.0 |
| | 10:50:30 | 7.06 | 1.73 | 3.63 | 6.45 | 7.06 |
| | 10.00.00 | 291.5 | Ø. 95 | 829 | 6 | Ø. 175 |
| | | 240.3 | -0.4080 | -0.66 | -10.73 | -30.0 |
| | 10:50:40 | 6.95 | 1.68 | 3.71 | 6.40 | 6.95 |
| | 10:00:70 | 291.6 | 2.28 | 830 | 6 | 0.166 |
| | | 240.5 | -0.3990 | -0.64 | -10.80 | -30.0 |
| | 10:50:50 | 7.06 | 1.74 | 3.66 | 6.54 | 7.06 |
| | 10.00.00 | 291.7 | 2.28 | 830 | 6 | Ø. 177 |
| | | 240.4 | -0.4130 | -0.67 | -10.60 | -30.0 |
| _ | 10:51:00 | 7.35 | 1.78 | 3.65 | 6.68 | 7.35 |
| | 10.51.00 | 291.7 | 2.28 | 829 | 6 | Ø. 186 |
| | | 240.8 | -0.4040 | -0.65 | -11.29 | -30.0 |
| | 10:51:10 | 7.30 | 1.77 | 3.66 | 6.66 | 7.30 |
| | 10.51.10 | 291.7 | 2.28 | 831 | 6 | 0.184 |
| | | 240.7 | -0.4020 | -0.65 | -11.27 | -30.0 |
| | 10:51:20 | 7.48 | 1.82 | 3.63 | 6.82 | 7.48 |
| | 10:51:50 | 291.7 | 2.28 | 831 | 6 | 0.195 |
| | | 240.7 | -0.3920 | -0.63 | -11.84 | -30.0 |
| | 10:51:30 | 7.73 | 1.83 | 3.67 | 6.90 | 7.73 |
| | 10.01.00 | 291.7 | 2.22 | 831 | 6 | 0.196 |
| | | 240.9 | -0.4010 | -0.65 | -11.96 | -30.0 |
| | 10:51:40 | 7.78 | 1.86 | 3.60 | 6.92 | 7.78 |
| | 10.01.70 | 291.7 | 1.59 | 831 | 6 | 0.204 |
| | | 240.5 | -0.4070 | -0.66 | -11.86 | -30.0 |
| | 10:51:50 | 7.75 | 1.82 | 3.66 | 6.87 | 7.75 |
| | 10.01.00 | 291.8 | 1.59 | 832 | 6 | 0.195 |
| | | 240.5 | -0.3970 | -0.64 | -12.11 | -30.0 |
| | 10:52:00 | 7.51 | 1.77 | 3.65 | 6.66 | 7.51 |
| | 10.02.00 | 291.8 | 1.59 | 832 | 6 | 0.184 |
| | | 240.5 | -0.4040 | -0.65 | -11.53 | -30.0 |
| | 10:52:10 | 7.15 | 1.68 | 3.73 | 6.42 | 7.15 |
| | 10.00.10 | 291.8 | 1.59 | 833 | 6 | 0.165 |
| | | 240.8 | -0.4010 | -0.65 | -11.06 | -30.0 |
| | 10:52:20 | 7.07 | 1.69 | 3.67 | 6.38 | 7.07 |
| | *************************************** | 291.9 | 1.59 | 832 | 6 | 0.168 |
| | | 240.6 | -0.4000 | -0.64 | -10.96 | -30.0 |
| | 10:52:30 | 7.06 | 1.67 | 3.73 | 6.40 | 7.06 |
| | | 291.9 | 1.57 | 831 | 6 | 0.164 |
| | | 240.7 | -0.4040 | -0.65 | -10.84 | -30.0 |

| CompTemp In Temp CompTemp Flow Sys. 6/C Sys.Drag Solution Sys. Broad Sys.Drag Solution Sys. Broad Sys.Drag Solution Sys.Broad Sys.Br | Station: | IPSC 2B Time | Fl-Fl dP | Act.G/C | Drag | Comp. dP | F1-F1 dP |
|--|-----------|-----------------|----------|--|-------|----------|---------------------|
| 291.8 | | | CompTemp | Opacity | Load | IBFM # | IBFM dh SonicAir |
| 240.6 -0.4000 -0.64 -10.93 - 10:52:50 7.09 1.69 3.68 6.40 291.6 1.41 828 6 240.4 -0.3950 -0.64 -11.13 - 10:53:00 7.09 1.69 3.70 6.42 291.7 1.41 828 6 240.8 -0.4100 -0.66 -10.73 - 10:53:10 7.12 1.68 3.74 6.44 291.7 1.40 828 6 240.7 -0.4050 -0.65 -10.91 - 10:53:20 7.10 1.68 3.73 6.43 291.7 1.40 828 6 240.7 -0.4050 -0.65 -10.91 - 10:53:30 6.98 1.65 3.70 6.26 291.6 1.39 828 6 291.6 1.39 828 6 291.6 1.39 828 6 291.7 1.30 831 6 291.7 1.30 831 6 240.8 -0.4000 -0.64 -11.01 - 240.8 -0.4000 -0.64 -10.82 - 291.7 1.30 831 6 0.291.6 1.30 832 6 0.291.6 1.30 831 6 0.291.6 | 4/10/1991 | 10:52:40 | | 1 | | 6.40 | 7.05 |
| 10:52:50 7.09 1.69 3.68 6.40 291.6 1.41 828 6 0 0 291.6 1.41 828 6 0 0 240.4 -0.3950 -0.64 -11.13 10:53:00 7.09 1.69 3.70 6.42 291.7 1.41 828 6 0 0 291.7 1.41 828 6 0 0 291.7 1.41 828 6 0 0 291.7 1.40 828 6 0 0 291.7 1.40 828 6 0 0 291.7 1.40 828 6 0 0 291.7 1.40 828 6 0 0 291.7 1.40 828 6 0 0 291.7 1.40 828 6 0 0 291.7 1.40 828 6 0 0 291.7 1.40 828 6 0 0 291.7 1.40 828 6 0 0 291.6 1.39 828 6 0 0 291.6 1.39 828 6 0 0 291.6 1.39 828 6 0 0 291.6 1.39 828 6 0 0 291.6 1.39 828 6 0 0 291.6 1.39 828 6 0 0 291.6 1.39 828 6 0 0 291.6 1.39 828 6 0 0 291.6 1.30 831 6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | | | | | | | 0. 165 |
| 291.6 | | | | -0.4000 | -0.64 | -10.93 | -30.0 |
| 240.4 -0.3950 -0.64 -11.13 -1 10:53:00 7.09 1.69 3.70 6.42 291.7 1.41 828 6 6 8 240.8 -0.4100 -0.66 -10.73 -1 10:53:10 7.12 1.68 3.74 6.44 291.7 1.40 828 6 0 0 240.7 -0.4050 -0.65 -10.91 -1 10:53:20 7.10 1.68 3.73 6.43 291.7 1.40 828 6 0 0 240.7 -0.4000 -0.64 -11.01 -1 10:53:30 6.98 1.65 3.70 6.26 291.6 1.39 828 6 0 0 240.6 -0.4000 -0.64 -11.01 -1 10:53:40 6.70 1.56 3.76 5.99 291.7 1.30 831 6 0 0 240.8 -0.4020 -0.65 -10.34 -10.82 291.7 1.30 831 6 0 0 240.8 -0.4020 -0.65 -10.34 -10.82 291.5 1.30 832 6 0 0 240.5 -0.4120 -0.66 -9.90 -1 10:54:00 6.59 1.55 3.77 5.99 291.6 1.30 832 6 0 0 240.6 -0.4050 -0.65 -10.10 -1 10:54:00 6.59 1.55 3.77 5.99 291.4 1.29 831 6 0 0 240.6 -0.4050 -0.65 -10.10 -1 10:54:20 6.57 1.56 3.77 6.01 6.50 -10.10 -1 10:54:20 6.57 1.56 3.77 6.01 6.50 -10.10 -1 10:54:20 6.57 1.56 3.77 6.01 6.50 -10.10 -1 10:54:20 6.57 1.56 3.77 6.01 6.50 -10.10 -1 10:54:20 6.57 1.56 3.77 6.01 6.50 -10.10 -1 10:54:20 6.57 1.56 3.77 6.01 6.50 -10.10 -1 10:54:20 6.57 1.56 3.77 6.01 6.50 -10.10 -1 10:54:20 6.57 1.56 3.77 6.01 6.50 -10.10 -1 10:54:20 6.57 1.56 3.77 6.01 6.50 -10.10 -1 10:54:20 6.57 1.56 3.77 6.01 6.50 -10.10 -1 10:54:20 6.57 1.56 3.77 6.01 6.50 -10.10 -1 10:54:30 6.61 1.56 3.78 6.02 6.00 -1 240.7 -0.4040 -0.65 -10.10 -1 10:54:40 6.62 1.54 3.81 6.01 6.01 6.00 -1 240.8 -0.4000 -0.65 -10.24 -1 10:55:00 6.85 1.59 3.77 6.16 6.16 6.16 6.2 6.2 6.2 6.0 6.2 6.2 6.0 6.2 6.2 6.0 6.2 6.2 6.0 6.2 6.2 6.0 6.2 6.2 6.0 6.2 6.2 6.0 6.2 6.2 6.0 6.2 6.2 6.0 6.2 6.2 6.0 6.2 6.2 6.0 6.2 6.2 6.0 6.2 6.2 6.0 6.2 6.2 6.0 6.2 6.2 6.2 6.0 6.2 6.2 6.2 6.2 6.2 6.2 6.2 6.2 6.2 6.2 | | 10:52:50 | | 1.69 | 3.68 | 6.40 | 7.09 |
| 10:53:00 7.09 1.69 3.70 6.42 291.7 1.41 828 6 6 0.2 240.8 -0.4100 -0.666 -10.73 -10:53:10 7.12 1.68 3.74 6.44 291.7 1.40 828 6 0.2 240.7 -0.4050 -0.65 -10.91 -10:53:20 7.10 1.68 3.73 6.43 291.7 1.40 828 6 0.2 240.7 -0.4000 -0.64 -11.01 -10:53:30 6.98 1.65 3.70 6.26 6 0.2 240.6 -0.4000 -0.64 -11.01 -10:53:30 6.98 1.65 3.70 6.26 6 0.2 240.6 -0.4000 -0.64 -10.82 -20:17 1.30 831 6 0.2 240.8 -0.4020 -0.65 -10.34 -20:17 1.30 831 6 0.2 240.5 -0.4120 -0.66 -9.90 -10:54:20 6.59 1.55 3.77 5.99 1.0 291.5 1.30 832 6 0.0 240.6 -0.4050 -0.65 -10.14 1.29 831 6 0.2 240.6 -0.4050 -0.65 -10.10 -10:54:20 6.57 1.54 3.79 5.99 1.0 291.4 1.29 831 6 0.2 240.6 -0.4050 -0.65 -10.10 -0.65 -10:10 -0. | | | | | 828 | 6 | 0. 168 |
| 291.7 1.41 828 6 0. 240.8 -0.4100 -0.666 -10.73 -240.8 291.7 1.40 828 6 0. 240.7 -0.4050 -0.65 -10.91 -220.7 1.40 828 6 0. 240.7 -0.4050 -0.65 -10.91 -220.7 1.40 828 6 0. 240.7 -0.4000 -0.64 -11.01 -220.7 1.40 828 6 0. 240.7 -0.4000 -0.64 -11.01 -220.7 1.20 828 6 0. 240.7 -0.4000 -0.64 -11.01 -220.7 1.20 828 6 0. 240.6 -0.4000 -0.64 -10.82 -201.6 1.39 828 6 0. 240.6 -0.4000 -0.64 -10.82 -201.7 1.30 831 6 0. 291.7 1.30 831 6 0. 291.7 1.30 831 6 0. 291.5 1.30 832 6 0. 240.5 -0.4120 -0.66 -9.90 -201.5 1.30 832 6 0. 240.5 -0.4120 -0.66 -9.90 -201.5 1.30 832 6 0. 240.6 -0.4050 -0.65 -10.10 -201.5 1.20 831 6 0. 240.6 -0.4050 -0.65 -10.10 -201.5 1.20 831 6 0. 240.9 -0.4010 -0.65 -10.10 -201.5 1.20 831 6 0. 240.9 -0.4010 -0.65 -10.10 -201.5 1.30 831 6 0. 240.7 -0.4040 -0.65 -10.10 -201.5 1.30 831 6 0. 240.7 -0.4040 -0.65 -10.10 -201.5 1.31 832 6 0. 240.7 -0.4040 -0.65 -10.10 -201.5 1.31 832 6 0. 240.8 -0.4000 -0.64 -10.25 -201.5 1.30 831 6 0. 240.7 -0.4040 -0.65 -10.10 -201.5 1.31 832 6 0. 240.8 -0.4000 -0.65 -10.10 -201.5 1.31 832 6 0. 240.8 -0.4000 -0.65 -10.10 -201.5 1.30 831 6 0.0 240.8 -0.4000 -0.65 -10.10 -201.5 1.30 831 6 0.0 240.8 -0.4000 -0.65 -10.10 -201.5 1.30 831 6 0.0 240.8 -0.4000 -0.65 -10.10 -201.5 1.30 831 6 0.0 240.8 -0.4000 -0.65 -10.10 -201.5 1.30 831 6 0.0 240.8 -0.4000 -0.65 -10.24 6.0 1.25 -201.5 1.40 833 6 0.0 240.8 -0.4000 -0.65 -10.24 6.0 1.25 -201.5 1.40 833 6 0.0 240.8 -0.4000 -0.65 -10.40 6 0.0 240.8 -0.4000 -0.65 -10.40 6 0.0 240.8 -0.4000 -0.65 -10.40 6 0.0 240.8 -0.4000 -0.65 -10.40 6 0.0 240.8 -0.4000 -0.65 -10.40 6 0.0 240.8 -0.4050 -0.65 -10.40 6 0.0 240.8 -0.4050 -0.65 -10.40 6 0.0 240.8 -0.4050 -0.65 -10.40 6 0.0 240.8 -0.4050 -0.65 -10.40 6 0.0 240.8 -0.4050 -0.65 -10.38 6.0 240.8 -0.4050 -0.65 -10.38 6.0 240.8 -0.4050 -0.65 -10.38 6.0 240.8 -0.4050 -0.66 -10.38 6.0 240.8 -0.4050 -0.66 -10.38 6.0 240.8 -0.4050 -0.66 -10.38 6.0 240.8 -0.4050 -0.66 -10.38 6.0 | | | 240.4 | -0.3950 | -0.64 | -11.13 | -30.0 |
| 240.8 -0.4100 -0.66 -10.73 -20.10:53:10 7.12 1.68 3.74 6.44 2.91.7 1.40 828 6 0 0.240.7 -0.4050 -0.65 -10.91 -20.10:53:20 7.10 1.68 3.73 6.43 2.91.7 1.40 828 6 0 0.240.7 -0.4000 -0.64 -11.01 -0.65 2.91.6 1.39 828 6 0 0.240.6 -0.4000 -0.64 -10.82 -0.240.6 -0.4000 -0.64 -10.82 -0.240.6 -0.4000 -0.64 -10.82 -0.240.6 -0.4000 -0.65 -10.34 -0.240.8 -0.4020 -0.65 -10.34 -0.240.8 -0.4020 -0.65 -10.34 -0.240.8 -0.4020 -0.65 -10.34 -0.240.5 -0.4120 -0.66 -9.90 -0.240.5 -0.4120 -0.66 -9.90 -0.240.5 -0.4120 -0.66 -9.90 -0.240.5 -0.4120 -0.66 -9.90 -0.240.5 -0.4120 -0.65 -10.10 -0.240.5 -0.4050 -0.65 -10.240 -0.250.5 -0.240.5 -0.4000 -0.65 -10.240 -0.250.5 -0.240.5 -0.4000 -0.65 -10.240 -0.250.5 -0.240.5 -0.4000 -0.65 -10.240 -0.250.5 -0.240.5 -0. | | 10:53:00 | | 1.69 | 3.70 | 6.42 | 7.09 |
| 10:53:10 7.12 1.68 3.74 6.44 291.7 1.40 828 6 0 240.7 -0.4050 -0.65 -10.91 -10:53:20 7.10 1.68 3.73 6.43 291.7 1.40 828 6 0 0.10:53:30 6.98 1.65 3.70 6.26 0.291.6 1.39 828 6 0 0.240.6 -0.4000 -0.64 -11.01 -10:53:40 6.70 1.56 3.76 5.99 0.291.7 1.30 831 6 0.240.8 -0.4020 -0.65 -10.34 -10:53:50 6.57 1.54 3.78 5.99 0.291.5 1.30 832 6 0.240.6 -0.4020 -0.65 -10.34 -10:54:00 6.59 1.55 3.77 5.99 0.291.5 1.30 832 6 0.240.6 -0.4050 -0.66 -10.10 -10:54:20 6.57 1.56 3.76 5.99 0.291.6 1.30 832 6 0.240.6 -0.4050 -0.65 -10.10 -10:54:20 6.57 1.56 3.77 5.99 0.291.6 1.30 832 6 0.240.6 -0.4050 -0.65 -10.10 -10:54:20 6.57 1.56 3.77 6.01 0.291.6 1.30 831 6 0.240.9 -0.4010 -0.65 -10.18 -10:54:20 6.57 1.56 3.77 6.01 0.291.6 1.30 831 6 0.240.7 -0.4040 -0.65 -10.10 -10:54:20 6.57 1.56 3.77 6.01 0.291.6 1.30 831 6 0.240.7 -0.4040 -0.65 -10.10 -10:54:20 6.57 1.56 3.77 6.01 0.291.6 1.30 831 6 0.240.7 -0.4040 -0.65 -10.10 -10:54:20 6.67 1.56 3.78 6.02 0.240.7 -0.4040 -0.65 -10.10 -10:54:20 6.67 1.56 3.78 6.02 0.240.7 -0.4040 -0.65 -10.10 -10:54:20 6.67 1.56 3.78 6.02 0.240.7 -0.4040 -0.65 -10.10 -10:54:20 6.61 1.56 3.78 6.02 0.240.7 -0.4040 -0.65 -10.10 -10:54:20 6.66 1.54 3.81 6.01 0.25 -10:24 -10:24 -10:25 -10:24 -10:25 -10:24 -10:24 -10:25 -10:24 -10:25 -10:24 -10:25 -10:24 -10:25 -10:24 -10:25 -10:24 -10:25 -10:24 | | | 291.7 | 1.41 | 828 | 6 | 0.168 |
| 291.7 | | | 240.8 | -0.4100 | -0.66 | -10.73 | -30.0 |
| 240.7 -0.4050 -0.65 -10.91 -2.65 | | 10:53:10 | 7.12 | 1.68 | 3.74 | 6.44 | 7.12 |
| 10:53:20 7.10 1.68 3.73 6.43 291.7 1.40 828 6 0 240.7 -0.4000 -0.64 -11.01 10:53:30 6.98 1.65 3.70 6.26 291.6 1.39 828 6 0 240.6 -0.4000 -0.64 -10.82 -1 10:53:40 6.70 1.56 3.76 5.99 6 291.7 1.30 831 6 0 240.8 -0.4020 -0.65 -10.34 -1 10:53:50 6.57 1.54 3.78 5.99 6 291.5 1.30 832 6 0.2 240.5 -0.4120 -0.66 -9.90 -1 10:54:00 6.59 1.55 3.77 5.99 6 291.4 1.29 831 6 0.2 240.6 -0.4050 -0.65 -10.10 -1 10:54:20 6.57 1.56 3.77 6.01 240.9 -0.65 -10.18 -1 10:54:20 6.57 1.56 3.77 6.01 240.9 -0.65 -10.18 -1 10:54:20 6.57 1.56 3.77 6.01 291.6 1.30 832 6 0.1 240.7 -0.4040 -0.65 -10.18 -1 10:54:30 6.61 1.56 3.77 6.01 291.6 1.30 831 6 0.1 240.7 -0.4040 -0.65 -10.10 -0.00 -0.65 -10.10 -0.65 -10.10 -0.65 -10.10 -0.65 -10.10 -0.65 -10.10 -0.65 -10.10 -0.65 -10.10 -0.65 -10.10 -0.65 -10.10 -0.65 -10.10 -0.65 -10.10 -0.65 -10.10 -0.65 -10.10 -0.65 -10.10 -0.65 -10.24 -0.66 -10.30 -0.65 -10.24 -0.66 -10.30 -0.65 -10.24 -0.66 -10.30 -0.65 -10.24 -0.66 -10.30 -0.65 -10.24 -0.66 -10.30 -0.65 -10.49 -0.65 - | | | 291.7 | 1.40 | 828 | 6 | 0.165 |
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| 10:54:10 6.58 1.54 3.79 5.99 6 291.4 1.29 831 6 0 240.9 -0.4010 -0.65 -10.18 -3 10:54:20 6.57 1.56 3.77 6.01 6 291.6 1.30 831 6 0 240.7 -0.4040 -0.65 -10.10 -3 10:54:30 6.61 1.56 3.78 6.02 6 291.5 1.31 832 6 0 240.3 -0.4000 -0.64 -10.25 -3 10:54:40 6.62 1.54 3.81 6.01 6 291.5 1.40 833 6 0 240.8 -0.4010 -0.65 -10.24 -3 10:54:50 6.77 1.60 3.76 6.16 6 291.6 1.40 832 6 0 240.6 -0.3960 -0.64 -10.60 -3 10:55:00 6.85 1.59 3.77 6.16 6.16 6 291.6 1.40 830 6 0 240.8 -0.4050 -0.65 -10.49 -3 10:55:10 6.89 1.60 3.79 6.21 6 291.5 1.40 831 6 0 240.8 -0.4120 -0.66 -10.38 -3 10:55:20 7.08 1.64 3.79 6.35 6.35 691.6 1.40 831 6 0 | | | | | | | -30.0 |
| 291.4 1.29 831 6 0.240.9 -0.4010 -0.65 -10.18 -3 10:54:20 6.57 1.56 3.77 6.01 6 291.6 1.30 831 6 0.3 240.7 -0.4040 -0.65 -10.10 -3 10:54:30 6.61 1.56 3.78 6.02 6 291.5 1.31 832 6 0.3 240.3 -0.4000 -0.64 -10.25 -3 10:54:40 6.62 1.54 3.81 6.01 6 291.5 1.40 833 6 0.3 240.8 -0.4010 -0.65 -10.24 -3 10:54:50 6.77 1.60 3.76 6.16 6 291.6 1.40 832 6 0.3 240.6 -0.3960 -0.64 -10.60 -3 10:55:00 6.85 1.59 3.77 6.16 6.16 6.16 291.6 1.40 830 6 0.3 240.8 -0.4050 -0.65 -10.49 -3 10:55:10 6.89 1.60 3.79 6.21 6.20 240.8 -0.4120 -0.66 -10.38 -3 10:55:20 7.08 1.64 3.79 6.35 6.35 6.31 6 0.3 | | 10:54:10 | | | | | 6.58 |
| 240.9 -0.4010 -0.65 -10.18 -10:54:20 6.57 1.56 3.77 6.01 6.01 291.6 1.30 831 6 0.240.7 -0.4040 -0.65 -10.10 -10:54:30 6.61 1.56 3.78 6.02 6.291.5 1.31 832 6 0.2540.3 -0.4000 -0.64 -10.25 -10:54:40 6.62 1.54 3.81 6.01 6.01 291.5 1.40 833 6 0.240.8 -0.4010 -0.65 -10.24 -10:54:50 6.77 1.60 3.76 6.16 6.16 291.6 1.40 832 6 0.240.6 -0.3960 -0.64 -10.60 -3.40.6 -0.3960 -0.64 -10.60 -3.40.6 -0.3960 -0.64 -10.60 -3.40.6 -3.40.8 -0.4050 -0.65 -10.49 -3.40.8 -0.4050 -0.65 -10.49 -3.40.8 -0.4050 -0.65 -10.49 -3.40.8 -0.4050 -0.65 -10.49 -3.40.8 -0.4050 -0.65 -10.49 -3.40.8 -0.4050 -0.65 -10.49 -3.40.8 -0.4050 -0.65 -10.49 -3.40.8 -0.4050 -0.66 -10.38 -3.40.8 -0.4120 -0.4120 -0.66 -10.38 -3.40.8 -0.4120 -0.4120 -0.66 -10.38 -3.40.8 -0.4120 -0 | | | | | | | 0.140 |
| 10:54:20 6.57 1.56 3.77 6.01 6 291.6 1.30 831 6 0 6 240.7 -0.4040 -0.65 -10.10 -10:54:30 6.61 1.56 3.78 6.02 6 240.3 -0.4000 -0.64 -10.25 -10:54:40 6.62 1.54 3.81 6.01 6 291.5 1.40 833 6 0 6 240.8 -0.4010 -0.65 -10.24 -10:54:50 6.77 1.60 3.76 6.16 6 291.6 1.40 832 6 0 6 240.6 -0.3960 -0.64 -10.60 -10:55:00 6.85 1.59 3.77 6.16 6 16 6 291.6 1.40 830 6 0 6 240.8 -0.4050 -0.65 -10.49 -10:55:10 6.89 1.60 3.79 6.21 6 240.8 -0.4050 -0.65 -10.49 -10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0 6 240.8 -0.4120 -0.66 -10.38 -10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0 6 25 291.6 1.40 831 6 0 6 25 291.6 1.40 831 6 0 6 25 291.6 1.40 831 6 0 6 25 240.8 -0.4120 -0.66 -10.38 -10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0 6 25 | | | | | | | -30.0 |
| 291.6 1.30 831 6 0.10 10:54:30 6.61 1.56 3.78 6.02 6 240.3 -0.4000 -0.64 -10.25 -10.10 240.3 -0.4000 -0.64 -10.25 -10.25 10:54:40 6.62 1.54 3.81 6.01 6 240.8 -0.4010 -0.65 -10.24 -10:54:50 6.77 1.60 3.76 6.16 6 291.6 1.40 832 6 0.10:55:00 6.85 1.59 3.77 6.16 6 291.6 1.40 830 6 0.10:55:10 6.89 1.60 3.79 6.21 6 240.8 -0.4050 -0.65 -10.49 -10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0.10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0.10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0.10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0.10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0.10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0.10:55:20 7.08 1.64 3.79 6.35 | | 10:54:20 | | i i | | | 6.57 |
| 240.7 -0.4040 -0.65 -10.10 -10.54:30 6.61 1.56 3.78 6.02 6 291.5 1.31 832 6 0.5 240.3 -0.4000 -0.64 -10.25 -1 10:54:40 6.62 1.54 3.81 6.01 6.01 291.5 1.40 833 6 0.6 240.8 -0.4010 -0.65 -10.24 -1 10:54:50 6.77 1.60 3.76 6.16 6 291.6 1.40 832 6 0.6 240.6 -0.3960 -0.64 -10.60 -1 10:55:00 6.85 1.59 3.77 6.16 6 291.6 1.40 830 6 0.6 240.8 -0.4050 -0.65 -10.49 -1 10:55:10 6.89 1.60 3.79 6.21 6 291.5 1.40 831 6 0.6 240.8 -0.4120 -0.66 -10.38 -1 10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0.6 | | | | | | | 0.142 |
| 10:54:30 6.61 1.56 3.78 6.02 6 291.5 1.31 832 6 0 240.3 -0.4000 -0.64 -10.25 -3 10:54:40 6.62 1.54 3.81 6.01 6 291.5 1.40 833 6 0 240.8 -0.4010 -0.65 -10.24 -3 10:54:50 6.77 1.60 3.76 6.16 6 291.6 1.40 832 6 0 240.6 -0.3960 -0.64 -10.60 -3 10:55:00 6.85 1.59 3.77 6.16 6 291.6 1.40 830 6 0 240.8 -0.4050 -0.65 -10.49 -3 10:55:10 6.89 1.60 3.79 6.21 6 291.5 1.40 831 6 0 240.8 -0.4120 -0.66 -10.38 -3 10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0 | | | | | | | -30.0 |
| 291.5 1.31 832 6 0 240.3 -0.4000 -0.64 -10.25 -3 10:54:40 6.62 1.54 3.81 6.01 6 291.5 1.40 833 6 0 240.8 -0.4010 -0.65 -10.24 -3 10:54:50 6.77 1.60 3.76 6.16 6 291.6 1.40 832 6 0 240.6 -0.3960 -0.64 -10.60 -3 10:55:00 6.85 1.59 3.77 6.16 6 291.6 1.40 830 6 0 240.8 -0.4050 -0.65 -10.49 -3 10:55:10 6.89 1.60 3.79 6.21 6 291.5 1.40 831 6 0 240.8 -0.4120 -0.66 -10.38 -3 10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0 | | 10:54:30 | | | | | 6.61 |
| 240.3 -0.4000 -0.64 -10.25 -1 10:54:40 6.62 1.54 3.81 6.01 6 291.5 1.40 833 6 0 240.8 -0.4010 -0.65 -10.24 -1 10:54:50 6.77 1.60 3.76 6.16 6 291.6 1.40 832 6 0 240.6 -0.3960 -0.64 -10.60 -1 10:55:00 6.85 1.59 3.77 6.16 6 291.6 1.40 830 6 0 240.8 -0.4050 -0.65 -10.49 -1 10:55:10 6.89 1.60 3.79 6.21 6 291.5 1.40 831 6 0 240.8 -0.4120 -0.66 -10.38 -1 10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0 | | 10.07.00 | | | | | 0.142 |
| 10:54:40 6.62 1.54 3.81 6.01 6.01 291.5 1.40 833 6 0.01 240.8 -0.4010 -0.65 -10.24 -10:54:50 6.77 1.60 3.76 6.16 6.291.6 1.40 832 6 0.240.6 -0.3960 -0.64 -10.60 -10:55:00 6.85 1.59 3.77 6.16 6.16 6.291.6 1.40 830 6 0.240.8 -0.4050 -0.65 -10.49 -10:55:10 6.89 1.60 3.79 6.21 6.21 6.291.5 1.40 831 6 0.240.8 -0.4120 -0.66 -10.38 -10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0.25 | | | | 1 | | | -30.0 |
| 291.5 1.40 833 6 0.5 240.8 -0.4010 -0.65 -10.24 -5 10:54:50 6.77 1.60 3.76 6.16 6 291.6 1.40 832 6 0.5 240.6 -0.3960 -0.64 -10.60 -5 10:55:00 6.85 1.59 3.77 6.16 6 291.6 1.40 830 6 0.5 240.8 -0.4050 -0.65 -10.49 -5 10:55:10 6.89 1.60 3.79 6.21 6 291.5 1.40 831 6 0.5 240.8 -0.4120 -0.66 -10.38 -5 291.6 1.40 831 6 0.5 | | 101.54.40 | | | | | 6.62 |
| 240.8 -0.4010 -0.65 -10.24 -10.54:50 6.77 1.60 3.76 6.16 6.291.6 1.40 832 6 0.240.6 -0.3960 -0.64 -10.60 -10.55:00 6.85 1.59 3.77 6.16 6.291.6 1.40 830 6 0.240.8 -0.4050 -0.65 -10.49 -10:55:10 6.89 1.60 3.79 6.21 6.291.5 1.40 831 6 0.240.8 -0.4120 -0.66 -10.38 -10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0.25 | | 10.07.40 | | | | | 0.139 |
| 10:54:50 6.77 1.60 3.76 6.16 6 291.6 1.40 832 6 0 240.6 -0.3960 -0.64 -10.60 -3 10:55:00 6.85 1.59 3.77 6.16 6 291.6 1.40 830 6 0 240.8 -0.4050 -0.65 -10.49 -3 10:55:10 6.89 1.60 3.79 6.21 6 291.5 1.40 831 6 0 240.8 -0.4120 -0.66 -10.38 -3 10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0 | | | | | | | -30.0 |
| 291.6 1.40 832 6 0.64 240.6 -0.3960 -0.64 -10.60 -3 10:55:00 6.85 1.59 3.77 6.16 6 291.6 1.40 830 6 0.240.8 -0.4050 -0.65 -10.49 -3 10:55:10 6.89 1.60 3.79 6.21 6 291.5 1.40 831 6 0.240.8 -0.4120 -0.66 -10.38 -3 10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0.55 | | 10.54.50 | | | | | 6.77 |
| 240.6 -0.3960 -0.64 -10.60 -10.55:00 6.85 1.59 3.77 6.16 6.291.6 1.40 830 6 0.240.8 -0.4050 -0.65 -10.49 -10:55:10 6.89 1.60 3.79 6.21 6.291.5 1.40 831 6 0.240.8 -0.4120 -0.66 -10.38 -10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0.25 | | 10.07.00 | | | | | 0.150 |
| 10:55:00 6.85 1.59 3.77 6.16 6 291.6 1.40 830 6 0 240.8 -0.4050 -0.65 -10.49 - 10:55:10 6.89 1.60 3.79 6.21 6 291.5 1.40 831 6 0 240.8 -0.4120 -0.66 -10.38 - 10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0 | | | | | | | -30.0 |
| 291.6 1.40 830 6 0.65 240.8 -0.4050 -0.65 -10.49 -10.55:10 6.89 1.60 3.79 6.21 6 291.5 1.40 831 6 0.66 -10.38 -10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0.66 | | 10.55.00 | | | | | 6.85 |
| 240.8 -0.4050 -0.65 -10.49 -3 10:55:10 6.89 1.60 3.79 6.21 6 291.5 1.40 831 6 0 240.8 -0.4120 -0.66 -10.38 -3 10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0 | | 10.33.00 | | | | | 0.149 |
| 10:55:10 6.89 1.60 3.79 6.21 6 291.5 1.40 831 6 0 240.8 -0.4120 -0.66 -10.38 -3 10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0 | | | | 1 | | | |
| 291.5 1.40 831 6 0 240.8 -0.4120 -0.66 -10.38 -3 10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0 | | 10.55.10 | | · · | | | -30.0 4.00 |
| 240.8 -0.4120 -0.66 -10.38 -; 10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 0. | | 16:00:16 | | | | | 6.89 |
| 10:55:20 7.08 1.64 3.79 6.35 291.6 1.40 831 6 05 | | | | | | | 0.150 -20.0 |
| 291.6 1.40 831 6 0 | | 10.55.00 | | | | | -30 .0 |
| | | 10:00:50 | | | | | 7.08 |
| - 41.3 - VCD4.09 | | | | | | | 0.157 |
| | | | C+1.0 | TU. 4000 | -0.00 | -10.04 | -30.0 |

| Station: | IPSC 2B Time | F1-F1 dP CompTemp In Temp | | Drag Load Sys. G/C | Comp. dP IBFM # Sys.Drag | Fl-Fl dF IBFM dh SonicAir |
|-----------|-----------------|---------------------------------|---------|--------------------------|--------------------------------|---------------------------------|
| 4/10/1991 | 10:55:30 | 7.23 | 1.67 | 3.75 | 6.44 | 7.23 |
| | | 291.5 | 1.39 | 830 | 6 | 0.164 |
| | | 240.9 | -0.4120 | -0.66 | -10.89 | -30.0 |
| | 10:55:40 | 7.24 | 1.67 | 3.77 | 6.45 | 7.24 |
| | | 2 9 1.5 | 1.30 | 831 | 6 | 0. 163 |
| | | 240.9 | -0.3990 | -0.64 | -11.26 | -30.0 |
| | 10:55:50 | 7.20 | 1.66 | 3.73 | 6.37 | 7.20 |
| | | 291.6 | 1.30 | 832 | 6 | 0. 162 |
| | | 240.7 | -0.4040 | -0.65 | -11.06 | -30.0 |
| | 10:56:00 | 6.97 | 1.60 | 3.79 | 6.23 | 6.97 |
| | | 291.6 | 1.29 | 831 | 6 | 0.151 |
| | | 240.7 | -0.4010 | -0.65 | -10.78 | -30.0 |
| | 10:56:10 | 6.91 | 1.58 | 3.85 | 6.22 | 6.91 |
| | | 291.4 | 1.30 | 831 | 6 | 0.146 |
| | | 240.6 | -0.3970 | -0.64 | -10.80 | -30.0 |
| | 10:56:20 | 6.90 | 1.61 | 3.77 | 6.22 | 6.90 |
| | | 291.5 | 1.30 | 831 | 6 | 0. 152 |
| | | 240.4 | -0.3950 | -0.64 | -10.84 | -30.0 |
| | 10:56:30 | 6.94 | 1.61 | 3.79 | 6.25 | 6.94 |
| | | 291.7 | 1.29 | 831 | 6 | 0. 152 |
| | | 240.6 | -0.4010 | -0.65 | -10.73 | -30.0 |
| | 10:56:40 | 6.94 | 1.61 | 3.80 | 6.26 | 6.94 |
| | | 291.6 | 1.29 | 830 | 6 | 0.152 |
| | | 240.5 | -0.3940 | -0.64 | -10.92 | -30.0 |
| | 10:56:50 | 6.93 | 1.59 | 3.83 | 6.23 | 6.93 |
| | | 291.9 | 1.29 | 832 | 6 | 0.148 |
| | | 240.6 | -0.3930 | -0.63 | -10.94 | -30.0 |
| | 10:57:00 | 6.93 | 1.60 | 3.80 | 6.22 | 6.93 |
| | | 291.8 | 1.29 | 832 | 6 | 0.150 |
| | | 240.8 | -0.4050 | -0.65 | -10.61 | -30.0 |
| | 10:57:10 | 6.91 | 1.62 | 3.77 | 6.24 | 6.91 |
| | | 291.7 | 1.29 | 832 | 6 | 0. 153 |
| | | 240.8 | -0.4060 | -0.65 | -10.55 | -30.0 |
| | 10:57:20 | 6.93 | 1.61 | 3.78 | 6.24 | 6.93 |
| | | 291.9 | 1.29 | 832 | 6 | 0. 152 |
| | | 240.6 | -0.4030 | -0.65 | -10.66 | -30.0 |
| | 10:57:30 | 6.70 | 1.57 | 3.78 | 6.07 | 6.70 |
| | | 291.9 | 1.28 | 832 | 6 | 0. 144 |
| | | 240.9 | -0.4040 | -0.65 | -10.28 | -30.0 |
| | 10:57:40 | 6.60 | 1.54 | 3 .8 2 | 6.03 | 6.60 |
| | | 291.9 | 1.20 | 832 | 6 | 0.139 |
| | | 240.7 | -0.4020 | -0.65 | -10.19 | -30.0 |
| | 10:57:50 | 6.64 | 1.53 | 3.84 | 6.02 | 6.64 |
| | | 291.9 | 1.20 | 834 | 6 | 0. 138 |
| | | 240.3 | -0.4110 | -0.66 | -10.01 | -30.0 |
| | 10:58:00 | 6.58 | 1.55 | 3.80 | 6.02 | 6.58 |
| | | 292 .0 | 1.21 | 833 | 6 | 0.140 |
| | | 241.4 | -0.4010 | -0.65 | -10.18 | -30.0 |
| | 10:58:10 | 6.63 | 1.53 | 3.84 | 6.03 | 6.63 |
| | | 292.0 | 1.20 | 832 | 6 | 0.138 |
| | | 240.5 | -0.4080 | -0.66 | -10.07 | -30.0 |

| Station: | | | | | | |
|-----------|---|---------------------|-----------------|------------------|--------------------|---------------------|
| ate | Time | F1-F1 dP | Act.G/C | Drag | Comp. dP | F1-F1 dP |
| | | CompTemp In Temp | Opacity Flow | Load Sys. G/C | IBFM # Sys.Drag | IBFM dh SonicAir |
| | T. T. 11 T. 12 T. 200 200 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | TH LEMP | LIUW | 3y5. 0/C | DAP DUAR | DOUTCHIL |
| 4/10/1991 | 10:58:20 | 6.59 | 1.55 | 3.79 | 6.01 | 6.59 |
| | | 291.9 | 1.20 | 831 | 6 | 0.141 |
| | | 240.7 | -0.3990 | -0.64 | -10.24 | -30.0 |
| | 10:58:30 | 6.55 | 1.52 | 3.85 | 6.00 | 6.55 |
| | | 292 .0 | 1.21 | 831 | 6 | 0.136 |
| | | 241.2 | -0.4050 | -0.65 | -10.03 | -30.0 |
| | 10:58:40 | 6.67 | 1.57 | 3.81 | 6.13 | 6.67 |
| | | 292 .0 | 1.29 | 830 | 6 | 0.145 |
| | | 241.2 | -0.3960 | -0.64 | -10.45 | -30.0 |
| | 10:58:50 | 6.84 | 1.58 | 3.84 | 6.20 | 6.84 |
| | | 291.9 | 1.30 | 831 | 6 | 0.146 |
| | | 241.5 | -0.4030 | -0.65 | -10.53 | -30.0 |
| | 10:59:00 | 6.86 | 1.57 | 3.85 | 6.20 | 6.86 |
| | | 292.1 | 1.29 | 830 | 6 | 0.145 |
| | | 241.1 | -0.3980 | -0.64 | -10.70 | -30.0 |
| | 10:59:10 | 6.99 | 1.61 | 3.83 | 6.32 | 6.99 |
| | | 292 .0 | 1.30 | 830 | 6 | 0. 152 |
| | | 241.1 | -0.3990 | -0.64 | -10.86 | -30.0 |
| | 10:59:20 | 7.18 | 1.65 | 3.81 | 6.43 | 7.18 |
| | | 292.1 | 1.30 | 829 | 6 | 0.159 |
| | | 241.0 | -0.4030 | -0.65 | -11.05 | -30.0 |
| | 10:59:30 | 7.23 | 1.65 | 3.80 | 6.43 | 7.23 |
| | | 292.2 | 1.30 | 828 | 6 | 0.160 |
| _ | | 241.1 | -0.4070 | -0.66 | -11.02 | -30.0 |
| | 10:59:40 | 7.23 | 1.67 | 3.77 | 6.45 | 7.23 |
| | | 292 .0 | 1.40 | 827 | 6 | 0.163 |
| | | 241.3 | -0.4030 | -0.65 | -11.13 | -30.0 |
| | 10:59:50 | 7.12 | 1.60 | 3.85 | 6.31 | 7.12 |
| | | 291.8 | 1.40 | 827 | 6 | 0.150 |
| | | 241.1 | -0.3980 | -0.64 | -11.10 | -30.0 |
| | 11:00:00 | 6.93 | 1.60 | 3.81 | 6.24 | 6.93 |
| | | 291.7 | 1.40 | 829 | 6 | 0.150 |
| | | 241.3 | -0.4030 | -0.65 | -10.66 | -30.0 |
| | 11:00:10 | 6.90 | 1.61 | 3.79 | 6.25 | 6.90 |
| | | 291.7 | 1.40 | 829 | 6 | 0.152 |
| | | 240.8 | -0.4080 | -0.66 | -10.49 | -30.0 |
| | 11:00:20 | 6.91 | 1.58 | 3.86 | 6.25 | 6.91 |
| | | 291.7 | 1.40 | 829 | 6 | 0.147 |
| | | 241.3 | -0.4100 | -0.66 | -10.45 | -30.0 |
| | 11:00:30 | 6.94 | 1.57 | 3.89 | 6.26 | 6.94 |
| | | 291.8 | 1.40 | 830 | 6 | 0.145 |
| | | 241.1 | -0.3980 | -0.64 | -10.82 | -30.0 |
| | 11:00:40 | 6.97 | 1.59 | 3.82 | 6.24 | 6.97 |
| | | 291.9 | 1.40 | 829 | 6 | 0.149 |
| | 44 00 00 | 241.7 | -0.4020 | -0.65 | -10.75 | -30.0 |
| | 11:00:50 | 6.92 | 1.58 | 3.85 | 6.25 | 6.92 |
| | | 291.8 | 1.39 | 829 | 6 | 0.147 |
| | | 241.2 | -0.4020 | -0.65 | -10.68 | -30.0 |
| | 11:01:00 | 6.92 | 1.57 | 3.88 | 6.24 | 6.92 |
| | | 291.8 | 1.40 | 830 | 6 | 0.145 |
| | | 241.2 | -0.4060 | -0.65 | -10.58 | -30.0 |

| Station: | IPSC 2B | | | | | |
|-----------|-----------|---------------|-----------------|------------------|--------------------|-----------------------|
| ate | Time | F1-F1 dP | | Drag | Comp. dP | F1-F1 dF |
| | | In Temp | Opacity Flow | Load Sys. G/C | IBFM # Sys.Drag | IBFM dh SonicAir |
| 4/10/1991 | 11:01:10 | 6.91 | 1.58 | 3.85 | 6.24 | 6.91 |
| | | 291.8 | 1.40 | 830 | 6 | 0.147 |
| | | 241.3 | -0.4050 | -0.65 | -10.58 | -30.0 |
| | 11:01:20 | 6.88 | 1.57 | 3.91 | 6.27 | 6.88 |
| | | 291.8 | 1.40 | 830 | 6 | 0.144 |
| | | 241.3 | -0.3980 | -0.64 | -10.72 | -30.0 |
| | 11:01:30 | 6.85 | 1.56 | 3.90 | 6.24 | 6.85 |
| | | 291.9 | 1.38 | 832 | 6 | 0.143 |
| | 11.01.10 | 241.0 | -0.4080 | -0.66 | -10.42 | -30.0 |
| | 11:01:40 | 6.83 | 1.56 | 3.93 | 6.26 | 6.83 |
| | | 292.0 | 1.20 | 831 | 6 | 0.142 |
| | 11:01:50 | 241.2 | -0.3980 | -0.64 | -10.65 | -30.0 |
| | 11:01:00 | 6.97 291.9 | 1.60 | 3.89 | 6.39 6 | 6.97 |
| | | 241.0 | 1.20 -0.3940 | 831 | -10.97 | 0.151 -30.0 |
| | 11:02:00 | 7.08 | 1.64 | -0.64 3.83 | -10.77 6.45 | 7.08 |
| | 11.00.00 | 292.2 | 1.20 | 832 | 6 | 0.158 |
| | | 241.1 | -0.4100 | -0.66 | -10.71 | -30.0 |
| | 11:02:10 | 7.09 | 1.64 | 3.83 | 6.42 | 7.09 |
| | 11100110 | 292.1 | 1.20 | 832 | 6 | 0.157 |
| | | 241.3 | -0.4090 | -0.66 | -10.75 | -30.0 |
| | 11:02:20 | 7.11 | 1.63 | 3.86 | 6.46 | 7.11 |
| | 11102120 | 292.0 | 1.20 | 832 | 6 | 0.156 |
| | | 241.6 | -0.4080 | -0.66 | -10.81 | -30.0 |
| | 11:02:30 | 7.02 | 1.61 | 3.87 | 6.38 | 7.02 |
| | | 291.8 | 1.20 | 832 | 6 | 0.152 |
| | | 241.7 | -0.4000 | -0.64 | -10.89 | -30.0 |
| | 11:02:40 | 7.07 | 1.61 | 3.89 | 6.42 | 7.07 |
| | | 291.8 | 1.20 | 831 | 6 | 0.152 |
| | | 241.4 | -0.3980 | -0.64 | -11.02 | -30.0 |
| | 11:02:50 | 7.11 | 1.64 | 3.84 | 6.43 | 7.11 |
| | | 291.8 | 1.19 | 832 | 6 | 0.157 |
| | | 241.9 | -0.3950 | -0.64 | -11.17 | -30.0 |
| | 11:03:00 | 7.14 | 1.63 | 3.86 | 6.46 | 7.14 |
| | | 291.8 | 1.20 | 832 | 6 | 0. 156 |
| | | 241.8 | -0.4020 | -0.65 | -11.02 | -30.0 |
| | 11:03:10 | 7.32 | 1.68 | 3.84 | 6.61 | 7.32 |
| | | 291.8 | 1.20 | 832 | 6 | 0.165 |
| | | 241.5 | -0.3990 | -0.64 | -11.38 | -30.0 |
| | 11:03:20 | 7.44 | 1.70 | 3.81 | 6.64 | 7.44 |
| | | 291.8 | 1.20 | 832 | 6 | 0.169 |
| | | 241.5 | -0.4070 | -0.66 | -11.34 | -30.0 |
| | 11:03:30 | 7.46 | 1.66 | 3.90 | 6.64 | 7.46 |
| | | 291.6 | 1.21 | 832 | 6 | 0.162 -30.0 |
| | 11.07.40 | 241.6 | -0.4000 | -0.64 | -11.57 | -3 0.0 7.37 |
| | 11:03:40 | 7.37 291.6 | 1.67 1.30 | 3.84 831 | 6.59 6 | 0.164 |
| | | 241.6 | -0.4110 | -0.66 | -11.12 | -30.0 |
| | 11:03:50 | 7.16 | 1.62 | -0.66 3.90 | 6.47 | 7.16 |
| | 11:200:01 | 291.5 | 1.04 | 3. 70 831 | 6 | 0.154 |
| | | 242.0 | -0.4090 | -Ø.66 | -10.86 | -30.0 |
| | | to The S W | O: TO/O | 0.00 | 20:00 | www |

| Station: | IPSC 2B Time | בו_בו אה | Act.G/C | Drag | Comp. dP | F1-F1 dF |
|-----------|-----------------|---------------|-----------------|------------------|-----------------|----------|
| | TAME | | Opacity | Load Sys. G/C | IBFM # | IBFM dh |
| 4/10/1991 | 11:04:00 | 7.07 | 1.60 | 3.87 | 6.34 | 7.07 |
| | | 291.6 | 1.30 | 832 | 6 | 0.150 |
| | | 241.4 | -0.3980 | -0.64 | -11.02 | -30.0 |
| | 11:04:10 | 6.92 | 1.57 | 3.88 | 6.24 | 6.92 |
| | | 291.6 | 1.30 | 833 | 6 | 0.145 |
| | | 242.1 | -0.4030 | -0.65 | -10.65 | -30.0 |
| | 11:04:20 | 6.91 | 1.54 | 3.95 | 6.25 | 6.91 |
| | | 291.5 | 1.29 | 832 | 6 | 0.140 |
| | | 242.3 | -0.4050 | -0.65 | -10.59 | -30.0 |
| | 11:04:30 | 6.87 | 1.56 | 3.91 | 6.24 | 6.87 |
| | | 291.5 | 1.29 | 833 | 6 | 0.143 |
| | | 241.8 | -0.4040 | -0.65 | -10.54 | -30.0 |
| | 11:04:40 | 6.92 | 1.56 | 3.92 | 6.24 | 6.92 |
| | | 291.4 | 1.21 | 832 | 6 | 0.142 |
| | | 241.5 | -0.4040 | -0.65 | -10.62 | -30.0 |
| | 11:04:50 | 6.90 | 1.57 | 3.89 | 6.23 | 6.90 |
| | 11101100 | 291.4 | 1.20 | 831 | 6 | 0.144 |
| | | 241.7 | -0.3990 | -0.64 | -10.72 | -30.0 |
| | 11:05:00 | 6.88 | 1.56 | 3.90 | 6.24 | 6.88 |
| | 11100100 | 291.6 | 1.20 | 830 | 6 | 0.143 |
| | | 241.8 | -0.4050 | -0.65 | -10.54 | -30.0 |
| | 11:05:10 | 6.88 | 1.56 | 3.93 | 6.26 | 6.88 |
| | 11.05.10 | 291.6 | 1.21 | 830 | 6 | 0.142 |
| | | 241.4 | -0.4000 | -0.64 | -10.67 | -30.0 |
| | 11:05:20 | 6.78 | 1.53 | 3.96 | 6.21 | 6.78 |
| | 11:00:00 | 291.6 | 1.20 | 3. 76 829 | 6.21 | Ø. 138 |
| | | 241.6 | -0.4020 | -0.65 | -10.47 | -30.0 |
| | 11:05:30 | 6.78 | 1.54 | -0.83 3.91 | 6.18 | 6.78 |
| | 11.60.06 | 291.6 | 1.19 | 830 | 6 | 0.140 |
| | | 241.5 | -0.4010 | -0.65 | -10.49 | -30.0 |
| | 11:05:40 | 6.83 | 1.56 | -0.83 3.94 | 6.28 | 6.83 |
| | 11.00.70 | 291.6 | | | 6 | 0.142 |
| | | 241.6 | 1.10 -0.4050 | 830 -0.65 | -10.46 | -30.0 |
| | 11:05:50 | 7.01 | 1.59 | -ø. 63 3. 92 | 6.37 | 7.01 |
| | 11:00:00 | 291.7 | 1.10 | 831 | 6.37 | 0.148 |
| | | | -0.4030 | -0.65 | -10.79 | -30.0 |
| | 11:06:00 | 241.6 7.02 | | | 6.37 | 7.02 |
| | 11:00:00 | | 1.58 | 3.94 | | 0.146 |
| | | 291.9 | 1.09 | 831 | 6 | |
| | 11.07.10 | 242.3 | -0.4050 | -0.65 | -10.75 | -30.0 |
| | 11:06:10 | 7.03 | 1.60 | 3.92 | 6.42 | 7.03 |
| | | 291.8 | 1.10 | 832 | 6 | 0.150 |
| | 44 000 000 | 241.2 | -0.3970 | -0.64 | -10.99 | -30.0 |
| | 11:06:20 | 7.01 | 1.55 | 3.98 | 6.31 | 7.01 |
| | | 291.8 | 1.10 | 831 | 6 | 0.141 |
| | | 241.8 | -0.4100 | -0.66 | -10.61 | -30.0 |
| | 11:06:30 | 6.97 | 1.57 | 3.95 | 6.36 | 6.97 |
| _ | | 291.7 | 1.11 | 830 | 6 | 0.145 |
| | | 241.3 | -0.3980 | -0.64 | -10.86 | -30.0 |
| | 11:06:40 | 7.05 | 1.59 | 3.94 | 6.40 | 7.05 |
| | | 291.8 | 1.20 | 832 | 6 | 0.148 |
| | | 242.2 | -0.4070 | - 0. 66 | -1 0. 75 | -30.0 |
| | | | | | | |

| Station: | IPSC 2B Time | F1-F1 dP | Act.G/C | Drag | Comp. dP | F1-F1 dF |
|-----------|-----------------|---------------|---------|--------------|----------|---------------------|
| | | | Opacity | _ | IBFM # | IBFM dh SonicAir |
| 4/10/1991 | 11:06:50 | 7.08 | 1.59 | 3.92 | 6.40 | 7.08 |
| | | 291.7 | 1.20 | 831 | 6 | 0.149 |
| | | 242.2 | -0.4070 | -0.66 | -10.79 | -30.0 |
| | 11:07:00 | 7.17 | 1.61 | 3.93 | 6.48 | 7.17 |
| | | 291.7 | 1.21 | 832 | 6 | 0. 152 |
| | | 242.2 | -0.4050 | -0.65 | -10.98 | -30.0 |
| | 11:07:10 | 7.32 | 1.64 | 3.9 2 | 6.57 | 7.32 |
| | | 291.6 | 1.20 | 833 | 6 | 0. 157 |
| | | 241.6 | -0.4000 | -0.64 | -11.35 | -30.0 |
| | 11:07:20 | 7.39 | 1.64 | 3.93 | 6.59 | 7.39 |
| | | 291.6 | 1.20 | 833 | 6 | 0.157 |
| | | 241.8 | -0.3990 | -0.64 | -11.49 | -30.0 |
| | 11:07:30 | 7.40 | 1.64 | 3.91 | 6.58 | 7.40 |
| | | 291.5 | 1.21 | 831 | 6 | 0. 158 |
| | | 241.5 | -0.3990 | -0.64 | -11.51 | -30.0 |
| | 11:07:40 | 7.17 | 1.58 | 3.97 | 6.41 | 7.17 |
| | | 291.7 | 1.21 | 830 | 6 | 0.146 |
| | | 241.5 | -0.4000 | -0.64 | -11.12 | -30.0 |
| | 11:07:50 | 7.01 | 1.57 | 3.95 | 6.36 | 7.01 |
| | | 291.6 | 1.20 | 832 | 6 | 0.145 |
| | | 241.5 | -0.4060 | -Ø.65 | -10.71 | -30.0 |
| | 11:08:00 | 6.93 | 1.52 | 4.00 | 6.22 | 6.93 |
| | | 291.7 | 1.20 | 832 | 6 | 0. 136 |
| | | 241.6 | -0.3950 | -0.64 | -10.89 | -30.0 |
| | 11:08:10 | 6.84 | 1.53 | 3.97 | 6.22 | 6.84 |
| | | 291.6 | 1.20 | 831 | 6 | 0.138 |
| | | 241.6 | -0.3950 | -Ø.64 | -10.74 | -30.0 |
| | 11:08:20 | 6.86 | 1.52 | 4.02 | 6.24 | 6.86 |
| | | 291.6 | 1.21 | 831 | 6 | 0.135 |
| | | 241.5 | -0.4100 | -0.66 | -10.38 | -30.0 |
| | 11:08:30 | 6.85 | 1.52 | 3.99 | 6.22 | 6.85 |
| | | 291.5 | 1.21 | 831 | 6 | 0.136 |
| | | 240 .8 | -0.3970 | -0.64 | -10.71 | -30.0 |
| | 11:08:40 | 6.85 | 1.56 | 3.92 | 6.24 | 6.85 |
| | | 291.6 | 1.21 | 831 | 6 | 0.142 |
| | | 241.4 | -0.4010 | -0.65 | -10.60 | -30.0 |
| | 11:08:50 | 6.88 | 1.53 | 3.98 | 6.25 | 6.88 |
| | | 291.7 | 1.21 | 830 | 6 | 0.138 |
| | | 241.2 | -0.4050 | -0.65 | -10.53 | -30.0 |
| | 11:09:00 | 6.82 | 1.51 | 3.98 | 6.15 | 6.82 |
| | | 291.6 | 1.20 | 831 | 6 | 0.134 |
| | | 242.1 | -0.4020 | -0.65 | -10.53 | -30.0 |
| | 11:09:10 | 6 .8 2 | 0.67 | 2.39 | 1.62 | 6.82 |
| | | 291.7 | 1.20 | 830 | 6 | 0. 026 |
| | | 241.3 | -0.4070 | -0.66 | -10.39 | -30.0 |
| | 11:09:20 | 6.76 | 0.18 | 0.71 | 0.13 | 6.76 |
| | | 291.5 | 1.20 | 831 | 6 | 0.002 |
| | | 241.4 | -0.4060 | -0.65 | -10.34 | -30.0 |
| | 11:09:30 | 6.77 | -0.32 | -0.26 | 0.08 | 6.77 |
| | | 291.5 | 1.19 | 831 | 6 | -0.006 |
| | | 241.1 | -0.4020 | -0.65 | -10.45 | -30.0 |
| | | | | | | |

| ate | IPSC 2B Time | F1-F1 dP CompTemp In Temp | Opacity | Drag Load Sys. G/C | Comp. dP IBFM # Sys.Drag | Fl-Fl dP IBFM dh SonicAir | |
|-----------|-----------------|---------------------------------|---------------|--------------------------|--------------------------------|--|-----|
| 4/10/1991 | 11:09:40 | 6.93 291.4 | -1.36 1.09 | 0.85 831 | -1.27 6 | 6.93 -0.109 | |
| | | 242.0 | -0.4050 | -0.65 | -10.61 | -30.0 | |
| | 11:09:50 | 7.05 | -2.49 | 0.65 | -1.99 | 7.05 | |
| | | 290.2 | 1.09 | 830 | 6 | -0.367 | |
| | | 241.4 | -0.4000 | -0.64 | -10.93 | -30.0 | |
| | 11:10:00 | 7.06 | -1.90 | 1.17 | -2.43 | 7.06 | |
| | | 287.2 | 1.10 | 830 | 6 | -0.214 | |
| | | 241.0 | -0.3930 | -0.63 | -11.14 | -30.0 | |
| | 11:10:10 | 7.01 | -1.74 | 1.24 | -2.34 | 7.01 | |
| | | 289.1 | 1.09 | 830 | 6 | -0.180 | |
| | | 241.8 | -0.3950 | -0.64 | -11.01 | -30.0 | |
| | 11:10:20 | 6.96 | -0.70 | 1.35 | -0.97 | 6.96 | |
| | | 289.4 | 1.10 | 830 | 6 | -0.029 | |
| | | 241.5 | -0.3990 | -0.64 | -10.82 | -30.0 | |
| | 11:10:30 | 7.02 | 0. 23 | -0.51 | -0.11 | 7.02 | |
| | | 289.3 | 1.19 | 830 | 6 | 0.003 | |
| | | 241.5 | -0.4000 | -0.64 | -10.89 | -30.0 | |
| | 11:10:40 | 7.07 | 0.18 | 0.04 | 0.01 | 7.07 | |
| | | 289.4 | 2.08 | 829 | 6 | 0.002 | |
| | | 241.3 | -0.3950 | -0.64 | -11.10 | -30.0 | |
| | 11:10:50 | 7.12 | 0.18 | 0.24 | 0.05 | 7.12 | |
| | | 289.4 | 2.08 | 830 | 6 | 0.00 2 | |
| | | 241.5 | -0.4080 | -0.66 | -10.83 | -30.0 | |
| | 11:11:00 | 7.30 | 0.18 | Ø. 36 | 0.07 | 7.30 | |
| | | 289.1 | 2.09 | 828 | 6 | 0.002 | |
| | | 241.6 | -0.4070 | -0.66 | -11.13 | -30.0 | |
| | 11:11:10 | 7.39 | 0.13 | 0.59 | 0.08 | 7 . 39 | |
| | | 288.9 | 2.08 | 829 | 6 | 0.001 | |
| | | 241.5 | -0.3970 | -0.64 | -11.55 | -30.0 | |
| | 11:11:20 | 7.34 | 0.00 | 0.00 | 0.08 | 7.34 | |
| | | 288.6 | 2.08 | 829 | 6 | 0.000 | |
| | | 241.5 | -0.4050 | -0.65 | -11.24 | -30.0 | |
| | 11:11:30 | 7.25 | 0.13 | 0.68 | Ø. Ø9 | 7.25 | |
| | | 288.6 | 2.07 | 830 | 6 | 0.001 | |
| | | 242.4 | -0.4100 | -0.66 | -10.97 | -30.0 | |
| | 11:11:40 | 7.11 | Ø. 26) | 0. 35 | 0.10 | 7.11 | |
| | | 288.3 | 1.99 | 830 | 6 | 0.004 Dh | |
| | | 241.4 | -0.4000 | -0.64 | -11.03 | -30.0 | |
| | 11:11:50 | 6.99 | (1.64) | 1.08 | 1.93 | 6.99 | |
| | | 288 .0 | 1.99 | 831 | 6 | 0.159 DN | |
| | | 241.4 | -0.4050 | -0.65 | -10.71 | -30.0 | - |
| | 11:12:00 | 6.80 | (2.64) | 1.40 | 4.12 | 6.80 Tust Atter | ٠ |
| | | 288.3 | 1.98 | 833 | 6 | 0.412 Just (1e0 | 11 |
| | | 241.5 | -0.4050 | -0.65 | -10.42 | 6.80 Just After 0.412 Just After -30.0 First Cleo 6.80 with Horn 0.407 with Horn | ۱ < |
| | 11:12:10 | 6.80 | 2.63 | 1.49 | 4.32 | 6.80 with HO'' | ٠ |
| | | 288.6 | 1.98 | 834 | 6 | = | |
| | | 241.3 | -0.4110 | -0.66 | -10.27 | -30.0 | |
| | 11:12:20 | 6.78 | (2.60) | 1.53 | 4.38 | 6.78 | |
| | | 289.4 | 1.99 | 832 | 6 | 0. 398 | |
| | | 241.7 | -0.4040 | -0.65 | -10.41 | -30.0 | |

| Station: | | E1 E1 10 | 0 | _ | 0 40 | e, e, uc |
|-----------|----------|---------------------|-----------------|------------------|-----------------|---------------------|
| ate | Time | F1-F1 dP | Act.G/C | Drag | Comp. dP | F1-F1 dF |
| | | CompTemp In Temp | Opacity Flow | Load Sys. G/C | IBFM # | IBFM dh SonicAir |
| A-1 | | TII LEMA | F1UW . | 5ys. 6/C | Sys.Drag | DOULTCHIL |
| 4/10/1991 | 11:12:30 | 6.77 | 2.59 | 1.56 | 4.45 | 6.77 |
| | | 290.0 | 2.55 | 830 | 6 | 0. 395 |
| | | 241.6 | -0.4050 | -0.65 | -10.37 | -30.0 |
| | 11:12:40 | 6.71 | 2.58 | 1.58 | 4.46 | 6.71 |
| | | 290.5 | 7.60 | 829 | 6 | 0. 392 |
| | | 241.3 | -0.4020 | -0.65 | -10.36 | -30.0 |
| | 11:12:50 | 6.74 | 2.56 | 1.62 | 4.53 | 6.74 |
| | | 290.8 | 7.60 | 828 | 6 | 0.385 |
| | | 241.5 | -0.4020 | -0.65 | -10.40 | -30.0 |
| | 11:13:00 | 6.75 | 2.59 | 1.61 | (4.56) | 6.75 |
| | | 291.0 | 7.59 | 828 | 6 | 0.394 |
| | | 241.2 | -0.4050 | -0.65 | -10.34 | -30.0 |
| | 11:13:10 | 6.64 | 2.57 | 1.62 | (4 . 55) | 6.64 |
| | | 291.2 | 7.60 | 830 | 6 | 0. 387 |
| | | 241.8 | -0.4090 | -0.66 | -10.08 | -30.0 |
| | 11:13:20 | 6.66 | 2.56 | 1.64 | (4.58) | 6.66 |
| | | 291.5 | 7.60 | 830 | 6 | 0.384 |
| | | 241.4 | -0.4020 | -0.65 | -10.29 | -30.0 |
| | 11:13:30 | 6.78 | 2.59 | 1.63 | (4.64) | 6.78 |
| | | 291.6 | 7.06 | 830 | 6 | 0.395 |
| | | 241.6 | -0.4050 | -0.65 | -10.38 | -30.0 |
| | 11:13:40 | 6.94 | 2.54 | 1.71 | (4.72) | 6.94 |
| | | 291.9 | 2.18 | 830 | - 6 | 0.378 |
| | | 241.6 | -0.4020 | -0.65 | -10.71 | -30.0 |
| | 11:13:50 | 6.96 | (2.59) | 1.66 | (4.70) | 6.96 |
| | | 291.9 | 2.18 | 830 | 6 | 0.394 |
| | | 241.5 | -0.4010 | -0.65 | -10.76 | -30.0 |
| | 11:14:00 | 6.97 | (2.57) | 1.69 | 4.73 | 6.97 |
| | | 292.1 | 2.18 | 830 | - 6 | 0.386 |
| | | 241.4 | -0.4040 | -0.65 | -10.70 | -30.0 |
| | 11:14:10 | 6.95 | 2.54 | 1.72 | (4.73) | 6.95 |
| | | 292.3 | 2.17 | 830 | <u> </u> | 0.377 |
| | | 242.2 | -0.4020 | -Ø.65 | -10.72 | -30.0 |
| | 11:14:20 | 6.98 | 2.55 | 1.72 | 4.76 | 6.98 |
| | | 292.2 | 2.18 | 831 | 6 | 0.382 |
| | | 241.4 | -0.4040 | -0.65 | -10.72 | -30.0 |
| | 11:14:30 | 6.96 | (2.55) | 1.72 | 4.76 | 6.96 |
| | | 292.4 | 2.12 | 831 | 6 | 0. 382 |
| | | 241.4 | -0.4120 | -0.66 | -10.48 | -30.0 |
| | 11:14:40 | 7.04 | 2.54 | 1.74 | 4.80 | 7.04 |
| | | 292.5 | 1.58 | 830 | 6 | 0.378 |
| | | 241.2 | -0.4060 | -0.65 | -10.76 | -30.0 |
| | 11:14:50 | 7.23 | (2.62) | 1.72 | 4.92 | 7.23 |
| | | 292.6 | 1.59 | 832 | 6 | 0.403 |
| | 11.15.00 | 241.5 | -0.4090 | -0.66 | -10.97 | -30.0 |
| | 11:15:00 | 7.29 | 2.60 | 1.75 | 4.94 | 7.29 |
| | | 292.5 | 1.58 | 831 | 6 | 0.395 |
| | 44-45-46 | 241.8 | -0.4080 | -0.66 | -11.08 | -30.0 |
| _ | 11:15:10 | 7.31 | (2.57) | 1.78 | 4.96 | 7.31 |
| | | 292.6 | 1.59 | 830 -0.44 | 6 11 79 | 0.386 -30.0 |
| | | 241.5 | -0.3980 | -0.64 | -11.39 | -30.0 |

| _Station: | IPSC 2B | | , i | | | |
|-----------|----------|---------------|-----------------|---------------|----------------------|----------------|
| ate | Time | F1-F1 dP | Act.6/C | Drag | Comp. dP | F1-F1 dP |
| | | CompTemp | Opacity | Load | IBFM # | IBFM dh |
| | | In Temp | Flow | Sys. G/C | Sys.Drag | SonicAir |
| 4/10/1991 | 11:15:20 | 7.31 | 2.59 | 1.76 | 4.95 | 7.31 |
| | | 292.6 | 1.59 | 830 | 6 | 0.392 |
| | | 241.7 | -0.4060 | -0.65 | -11.17 | -30.0 |
| | 11:15:30 | 7.13 | 2.54 | 1.77 | 4.89 | 7.13 |
| | | 292.6 | 1.56 | 830 | 6 | Ø. 379 |
| | | 241.6 | -0.3990 | -0.64 | -11.09 | -30.0 |
| | 11:15:40 | 6.96 | 2.54 | 1.75 | 4.82 | 6 .96 |
| | | 292.6 | 1.39 | 831 | 6 | 0.379 |
| | | 241.6 | -0.4040 | -0.65 | -10.69 | -30.0 |
| | 11:15:50 | 6.74 | 2.47 | 1.77 | 4.72 | 6.74 |
| | | 292.8 | 1.39 | 829 | 6 | Ø. 356 |
| | 44 44 22 | 241.5 | -0.4040 | -0.65 | -10.36 | -30.0 |
| | 11:16:00 | 6.76 | 2.45 | 1.79 | 4.73 | 6.76 |
| | | 292.7 | 1.39 | 829 | 6 | 0.351 |
| | 11:16:10 | 241.5 | -0.4050 | -0.65 | -10.35 | -30.0 0.00 |
| | 11:10:10 | 0.00 0.0 | 0.00 0.00 | 0.00 | 0.00 0 | 0.000 |
| | | Ø. Ø | 0.000 0.0000 | 0 0.00 | 0.00 | 0.0 |
| | 11:16:20 | 6.76 | 2.47 | 1.78 | 4.74 | 6.76 |
| | 11:10:00 | 292.7 | 1.40 | 830 | 6 | 0.356 |
| | | 241.3 | -0.4070 | -0.66 | -10.31 | -30.0 |
| | 11:16:30 | 6.75 | 2.48 | 1.77 | 4.76 | 6.75 |
| | 11110100 | 292.7 | 1.39 | 831 | 6 | 0.361 |
| | | 241.6 | -0.3980 | -0.64 | -10.53 | -30.0 |
| | 11:16:40 | 6.76 | 2.47 | 1.78 | 4.76 | 6.76 |
| | | 292.8 | 1.30 | 831 | 6 | 0.357 |
| | | 241.4 | -0.3980 | -0.64 | -10.54 | -30.0 |
| | 11:16:50 | 6.72 | 2.46 | 1.78 | 4.73 | 6.72 |
| | | 292 .9 | 1.29 | 831 | 6 | 0. 354 |
| | | 241.5 | -0.4010 | -0.65 | -10.40 | -30.0 |
| | 11:17:00 | 6.68 | 2.45 | 1.81 | 4.79 | 6.68 |
| | | 292.8 | 1.29 | 830 | 6 | 0. 352 |
| | | 241.6 | -0.3960 | -0.64 | -10.47 | -30.0 |
| | 11:17:10 | 6.66 | 2.46 | 1.81 | 4.80 | 6.66 |
| | | 292.9 | 1.29 | 831 | 6 | 0. 354 |
| | | 241.0 | -0.4030 | -0.65 | -10.24 | -30.0 |
| | 11:17:20 | 6.70 | 2.45 | 1.83 | 4.84 | 6.70 |
| | | 292.9 | 1.29 | 831 | 6 | 0.351 |
| | | 241.4 | -0.4090 | -0.66 | -10.17 | -30.0 |
| | 11:17:30 | 6.84 | 2.52 | 1.82 | 4.96 | 6.84 |
| | | 292.8 | 1.29 | 830 | 6 | 0.372 |
| | | 241.3 | -0.4070 | -0.66 | -10.42 | -30.0 |
| | 11:17:40 | 6.94 | 2.53 | 1.83 | 5.01 | 6.94 |
| | | 292.9 | 1.20 | 830 | 6 | 0. 376 |
| | 44-47.50 | 241.0 | -0.4030 | -0.65 | -10.68 | -30.0 |
| | 11:17:50 | 6.91 | 2.57 | 1.80 | 5.02 | 6.91 |
| | | 292.9 | 1.20 -0.4060 | 831 -0 65 | 6 -1 0. 55 | 0.388 -30.0 |
| | 11:18:00 | 241.2 6.94 | -0.4060 2.52 | -0.65 1.84 | -10.55 5.01 | -30.0 6.94 |
| _ | 11:10:00 | 293.0 | 1.19 | 832 | J. 01 | 0.371 |
| | | 241.4 | -0.4080 | -0.66 | -10.55 | -30.0 |
| | | L-710 T | v. 7000 | ψ. υσ | 140.00 | oe.v |

| Station: | IPSC 2B Time | F1-F1 dP | Act.G/C | Drag | Comp. dP | F1-F1 dP |
|--|-----------------|---------------|--------------------------|-------------|----------------|-----------------------|
| | | | Opacity | Load | IBFM # | IBFM dh |
| with a second between the transfer of the tran | | - | | | | |
| 4/10/1991 | 11:18:10 | 6.91 | 2.53 | 1.81 | 4.96 | 6.91 |
| | | 293.1 | 1.20 | 832 | 6 | 0.375 |
| | 44-40-00 | 241.4 | -0.4020 | -0.65 | -10.66 | -30.0 |
| | 11:18:20 | 6.90 | 2.53 | 1.82 | 4.98 | 6.90 |
| | | 293.0 | 1.20 | 832 | 6 | 0. 374 |
| | 11:18:30 | 241.8 6.94 | -0.4170 2.51 | -0.67 | -10.26 5.00 | -30.0 |
| | 11:10:30 | 293.0 | 1.20 | 1.84 831 | 3.00 6 | 6.94 0.369 |
| | | 241.6 | -0.4030 | -0.65 | -10.68 | -30.0 |
| | 11:18:40 | 7.07 | - 0.40 30 2.53 | 1.85 | 5.07 | 7.07 |
| | 11:10:40 | 293.1 | 2.J3 1.20 | 832 | J. Ø7 | 0.375 |
| | | 241.6 | -0.4010 | -0.65 | -10.94 | -30.0 |
| | 11:18:50 | 7.25 | 2.58 | 1.84 | 5.14 | -3 0.0 7.25 |
| | 11:10:00 | 7.cu 293.0 | 1.20 | 830 | 5.14 | 0.3 9 0 |
| | | 241.7 | -0.4000 | -0.64 | -11.24 | -30.0 |
| | 11:19:00 | 7.27 | | | 5.15 | -3 0.0 7.27 |
| | 11:15:00 | 293.1 | 2.58 1.21 | 1.84 831 | J. 1J | 0.391 |
| | | 241.6 | -0.4030 | -0.65 | -11.19 | -30.0 |
| | 11:19:10 | 7.30 | 2.57 | 1.85 | 5.14 | 7.30 |
| | 11:17:10 | 293.1 | 1.21 | 831 | J. 14 | 0.388 |
| | | 241.4 | -0.4040 | -0.65 | -11.21 | -30.0 |
| | 11:19:20 | 7.14 | 2.53 | 1.85 | 5.06 | 7.14 |
| | 11.19.00 | 293.0 | 1.20 | 831 | J. 66 | 0.374 |
| | | 241.6 | -0.4000 | -0.64 | -11.07 | -30.0 |
| | 11:19:30 | 6.97 | 2.47 | 1.88 | 5.02 | 6.97 |
| | 11.17.00 | 293.1 | 1.20 | 831 | 6 | 0.358 |
| | | 241.8 | -0.4040 | -0.65 | -10.71 | -30.0 |
| | 11:19:40 | 6.82 | 2.40 | 1.88 | 4.84 | 6.82 |
| | 11.17.70 | 293.2 | 1.20 | 830 | 6 | 0.337 |
| | | 241.3 | -0.4010 | -0.65 | -10.55 | -30.0 |
| | 11:19:50 | 6.81 | 2.40 | 1.89 | 4.86 | 6.81 |
| | | 293.2 | 1.20 | 829 | 6 | 0.336 |
| | | 241.7 | -0.4000 | -0.64 | -10.56 | -30.0 |
| | 11:20:00 | 6.78 | 2.38 | 1.89 | 4.82 | 6.78 |
| | | 293.2 | 1.19 | 829 | 6 | 0.331 |
| | | 240.9 | -0.3970 | -0.64 | -10.60 | -30.0 |
| | 11:20:10 | 6.80 | 2.42 | 1.86 | 4.84 | 6.80 |
| | | 293.2 | 1.20 | 831 | 6 | 0.344 |
| | | 241.4 | -0.3970 | -0.64 | -10.63 | -30.0 |
| | 11:20:20 | 6.80 | 2.39 | 1.89 | 4.85 | 6.80 |
| | | 293.1 | 1.20 | 830 | 6 | 0.334 |
| | | 241.6 | -0.4060 | -0.65 | -10.38 | -30.0 |
| | 11:20:30 | 6.80 | 2.39 | 1.89 | 4.86 | 6.80 |
| | | 293.2 | 1.19 | 830 | 6 | 0.334 |
| | | 241.6 | -0.4030 | -0.65 | -10.46 | -30.0 |
| | 11:20:40 | 6.76 | 2.43 | 1.85 | 4.84 | 6.76 |
| _ | | 293.2 | 1.20 | 830 | 6 | Ø. 346 |
| | | 241.4 | -0.4050 | -0.65 | -10.36 | -30.0 |
| | 11:20:50 | 6.75 | 2.42 | 1.89 | 4.91 | 6.75 |
| | | 293.2 | 1.20 | 830 | 6 | 0.343 |
| | | 241.8 | -0.4010 | -0.65 | -10.45 | -30.0 |
| | | | | | | |

Appendix H

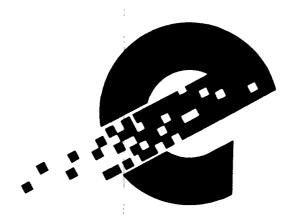
Environmental Consulting Company's

1991 Fabric Filter Bag Test Report

and

Grubb Filtration Testing Services, Incorporated's

1991 Fabric Filter Bag Test Report



Environmental Consultant Company

PREPARED FOR:

INTERMOUNTAIN POWER COMPANY

DELTA, UTAH

SEPTEMBER 25, 1991

TLN 9128

Environmental Consultant Company

dedicated to filtration science . . .

P.O. Box 42537 • Phoenix, AZ 85080 • 602-582-5155 Laboratory: 2401 W. Behrend Dr., Suite 1 • Phoenix, AZ 85027 RECEIVED

SEP 27 1991

PURCHASSAG

September 25, 1991 TLN 9128 Page 1

REPORT

INTERMOUNTAIN POWER SERVICE CORPORATION

REFERENCE: TLN 7774 OF MARCH 16, 1990

Twelve used filter bags were submitted for testing and evaluation.

These bags are the annual sampling for performance evaluations.

Unit 2 Compartment B-2 specimens are involved in sonic horn evaluations and one sample is before horn firing with the added sample after sonic horn firing.

The bags were labeled as follows:

| UNIT | COMPARTMENT | <u>BAG</u> |
|------|-------------|------------------|
| 2 | B-2 | J-11 AFTER HORN |
| 2 | B-2 | M-13 BEFORE HORN |
| 2 | B-4 | 0-20 |
| 2 | B-4 | D-18 |
| 2 | C-06 | I-12 |
| 2 | A-2 | G-1 |
| 2 | A-101 | E-1 |
| 1 | B-2 | R-16 |
| 1 | A-7 | J-20 |
| 1 | B-10 | 0-20 |
| 1 | A-1 | G-1 |
| 1 | C-06 | C-12 |

All bags were sampled from the G.E.E.S.I. reverse air cleaning baghouse collecting fly ash particulate.

Attached are the results of the testing data.



UNIT 2 (SONIC TRIAL):

Bag specimen 2-B-2-M-13 (before sonic) exhibited low as received flow capacity throughput characteristics.

This bag (M-13) generated similar flow acceptance data to the Unit 2 data in TLN 7774 of March 16, 1990. The retained filter cake on M-13 exhibited moisture induced dust agglomerations and accounts for one factor in reduced capacity. Photo A is a view of the collection surface on M-13 revealing these surface nodulas with flow acceptances restricted to the voids between the nodulas.

In contrast, Bag 2-B-2-J-11 (after sonic) did demonstrate an elevated flow throughput capacity level compared to M-13. Examination of the J-11 collection surface did reveal some degree of nodula discharge however, substantial levels of loose residual dust normally embedded in the voids of the texturized yarn structure did discharge. Photo B is a view of these retained nodulas after sonic impact.

Photo C is a view of M-13 texturized yarns (as received) showing high embedded fine particles within the voids and further contributes to low throughput capacity.

Bag J-11 yielded lower embedded fine particulate no doubt the result of the sonic power impact (Photo D).

It is apparent that the sonic power is contributing to higher loose residual dust release however generates minor agglomerate release. The net effect is higher throughput. The agglomerates will not release under the cleaning action due to fiber encapsulation. Photo E is a view of the agglomerate structure encapsulating the strong fiberglass fibers and is preventing release.

Again, the sonic system is influencing throughput as a direct result of improved loose dust discharge characteristics.

The nodulas as the result of the bonding forces of predominately hygroscopic calcium sulphate salt resulting from the reaction between calcium oxide ash particulate and sulfur oxide gases.

In contrast with available moisture, the salts will act as a bonding agent forming the enlarged nodula.

The sulphates are at a 4.59% by weight on Bag M-13 and 4.38% by weight on Bag J-11 indicating the low nodula release levels being experienced.

UNIT 2:

The remaining Unit 2 bags all yielded generally low as received flow throughput acceptances in profile resulting from agglomerates (Photo F).

It was noted that the top areas are significantly closer to the corresponding bag averages in contrast to TLN 7774 where lower top flows were experienced compared to the corresponding bag averages. It is apparent that the accumulated fines common to the top area have discharged to some extent and/or agglomerated allowing the discharge.

All seven bags from Unit 2 exhibited good collapse patterns common to previous data indicative of both proper tensioning levels and reverse air flow distribution.

All seven bags yielded nominal retained levels in all physical properties of strength and flex endurances. The current losses are all attributed to normal physical fatigue resulting from service use. There is no evidence of any chemical or thermal deterioration.

These specimens are rated at a general termination factor of 40% to 45% terminated.

Very often, fiberglass bags do not decline from equilibrium status in physical properties for several years of service however, once measurable fatigue is generated decline continues to termination. The bags are currently at a monthly 1.11% decline rate based on TLN 7774 data.

UNIT 1:

Again, all Unit 1 bags exhibited higher flow capacity throughput resulting from a more porous cake structure. Photo G is a microscopic view typical to all Unit 1 bags revealing the

September 25, 1991 TLN 9128 Page 4

generally porous non-agglomerated cake structure.

Again similar to TLN 7774 data, release properties under reverse air are generally good as shown by Photo H.

These bags (Unit 1) continue to have a lower sulphate salt extraction level with 2.81% by weight. It is apparent that Unit 1 has not experienced the moisture level of Unit 2 as Unit 1 sulphates are not in a state of agglomeration.

All Unit 1 specimens generated common declines in physical strength and flex properties resulting from nominal physical service use fatigue.

All bags are under generally good upward tensioning forces with no abnormal abrasion detected.

These bags are rated at a termination factor of 55% to 65%.

This data would reflect a monthly fatigue rate of 1.39% based on the TLN 7774 data.



Date: 9-25-91

TLN: 9128

Page:

dentification: 1-A-1-G1 Fiber Content: ECDE

Weave: 3 X 1 TWILL Count: 43 X 24 Fabric Construction: WOVEN

Yarn System- Warp/Length: 37-1/0F Filling Width: 75-1/2T+75-1/0F

Avg. Weight [oz/sq yd]: 13.59 Thickness [inches]: .013 Density Factor: .807

Treatment- Physical Type: NONE Chemical Type: A.R.

% Ignition Loss [LOI] ---> 500°F/1 Hr: 0.08% 1150°F/1 Hr: 4.12%

% Extractable Matter: SULPHATES Acid Alkaline [PH]: 11.35

Fabrication Hardware: C.R.

Seaming: CHAIN Cuffing: LOCK Sewing Thread: ECB

Ring Cover: LOCK Fabrication Rating: GOOD

| | | | | 1 421 1040101 | | |
|----------------------|-----------|----------|----------|---------------|--------|--------|
| PROFILE DATA | | | | TOP | CENTER | воттом |
| | | As Recei | ved | 23.08 | 22.95 | 22.87 |
| Weight [oz/s | q yd] | Cleaned | | 17.01 | 16.78 | 16.54 |
| | | Cleaned | (Washed) | 13.62 | 13.56 | 13.57 |
| Permeability | | As recei | ved | 2.11 | 2.15 | 2.29 |
| CFM/sq ft | | Cleaned | | 7.1 | 7.3 | 7.5 |
| @ .5" H2O | | Cleaned | (Washed) | 55.8 | 56.1 | 58.5 |
| Breaking Strength | Warp/Leng | th | | 387 | 395 | 382 |
| lbs/inch | Filling/W | idth | | 223 | 227 | 221 |
| Breaking Strength | Warp/Leng | th | | 35.93% | 34.60% | 36.75% |
| % Loss | Filling/W | idth | | 36.10% | 34.96% | 36.68% |
| Mullen Burst | (lbs/sq i | nch) | | 494 | 498 | 489 |
| Mullen Burst | % Loss | | | 39.98% | 39.49% | 40.58% |
| Flex Cycles | | Warp | | 21779 | 22027 | 21438 |
| [MIT Method] | | Fill | | 1704 | 1719 | 1695 |
| Flex Cycles | | Warp | Mr | 56.44% | 55.95% | 57.12% |
| Loss | | Fill | | 53.92% | 53.52% | 54.16% |
| Other Testin | g | | | | | |



Date: 9-25-91

TLN: 9128

Page:

dentification: 1-C-06-C12

Fiber Content: ECDE

Fabric Construction: WOVEN Weave: 3 X 1 TWILL Count: 44 X 24

Yarn System- Warp/Length: 37-1/0F Filling Width: 75-1/2T+75-1/0F

Avg. Weight [oz/sq yd]: 13.74 Thickness [inches]: .014 Density Factor: .757

Treatment- Physical Type: NONE

Chemical Type: A.R.

% Ignition Loss [LOI] ---> 500° F/1 Hr: 0.21°

1150°F/1 Hr: 4.75%

% Extractable Matter: SULPHATES

Acid Alkaline [PH]: 11.40

Fabrication

Hardware: C.R.

Seaming: CHAIN Cuffing: LOCK

Sewing Thread: ECB

Ring Cover: LOCK

Fabrication Rating: GOOD

| | | , , , , , , , , , , , , , , , , , , , | | · · · · · · · · · · · · · · · · | |
|--|----------|---------------------------------------|--------|---------------------------------|--------|
| PROFILE DATA | | | TOP | CENTER | воттом |
| 77 75 77 70 70 70 10 10 10 10 10 10 10 10 10 10 10 10 10 | | As Received | 23.25 | 23.15 | 23.11 |
| Weight [oz/s | q yd] | Cleaned | 17.30 | 17.23 | 17.05 |
| | | Cleaned (Washed) | 13.75 | 13.76 | 13.70 |
| Permeability | | As received | 1.97 | 2.08 | 2.15 |
| CFM/sq ft | | Cleaned | 7.0 | 7.1 | 7.4 |
| @ .5" H2O | | Cleaned (Washed) | 43.5 | 43.7 | 42.5 |
| Breaking | Warp/Len | gth | 396 | 398 | 392 |
| Strength - lbs/inch | Filling/ | Width | 231 | 230 | 220 |
| Breaking | Warp/Len | gth | 34.44% | 34.11% | 35.10% |
| Strength % Loss | Filling/ | Width | 33.81% | 34.20% | 36.96% |
| Mullen Burst | (lbs/sq | inch) | 499 | 512 | 501 |
| Mullen Burst | % Loss | | 39.37% | 37.79% | 39.13% |
| Flex Cycles | | Warp | 22381 | 23516 | 22282 |
| [MIT Method] | | Fill | 1753 | 1742 | 1702 |
| Flex Cycles | | Warp | 55.24% | 52.97% | 55.44% |
| Loss | | Fill | 52.60% | 52.89% | 53.98% |
| Other Testin | g | | | | |



Date: 9-25-91

TLN: 9128

Page:

dentification: 1-A-7-J-20

Fiber Content: ECDE

Fabric Construction: WOVEN Weave: 3 X 1 TWILL Count: 44 X 24

Yarn System- Warp/Length: 37-1/0F Filling Width: 75-1/2T+75-1/0F

Avg. Weight [oz/sq yd]: 13.79 Thickness [inches]: .015 Density Factor: .760

Treatment- Physical Type: NONE

Chemical Type: A.R.

% Ignition Loss [LOI] ---> 500°F/1 Hr: 0.24%

1150°F/1 Hr: 5.08%

% Extractable Matter: SULPHATES

Acid Alkaline [PH]: 11.40

Fabrication

Hardware: C.R.

Seaming: CHAIN Cuffing: LOCK

Sewing Thread: ECB

Ring Cover: LOCK Fabrication Rating: GOOD

| PROFILE DATA | | TOP | CENTER | BOTTOM |
|----------------|---------------|------------|--------|--------|
| | As Received | 23.39 | 23.31 | 23.20 |
| Weight [oz/sq | yd] Cleaned | 17.39 | 17.44 | 17.19 |
| | Cleaned (Wash | hed) 13.80 | 13.79 | 13.79 |
| Permeability | As received | 2.14 | 2.20 | 2.27 |
| CFM/sq ft | Cleaned | 7.1 | 7.1 | 7.3 |
| @ .5" H2O | Cleaned (Wash | hed) 43.5 | 42.4 | 42.8 |
| | arp/Length | 415 | 422 | 416 |
| Strength — F | illing/Width | 225 | 232 | 221 |
| | arp/Length | 31.29% | 30.13% | 31.13% |
| Strength — F | illing/Width | 35.53% | 33.52% | 36.68% |
| Mullen Burst (| lbs/sq inch) | 511 | 514 | 511 |
| Mullen Burst % | Loss | 37.91% | 37.55% | 37.91% |
| Flex Cycles | Warp | 21886 | 21998 | 21526 |
| [MIT Method] | Fill | 1753 | 1801 | 1701 |
| Flex Cycles | Warp | 56.23% | 56.00% | 56.95% |
| % Loss | Fill | 52.60% | 51.30% | 54.00% |
| Other Testing | | | | |



Date: 9-25-91

TLN: 9128

Page:

dentification: 1-B-10-020

Fiber Content: ECDE

Fabric Construction: WOVEN Weave: 3 X 1 TWILL Count: 44 X 24

Yarn System- Warp/Length: 37-1/0F Filling Width: 75-1/2T+75-1/0F

Avg. Weight [oz/sq yd]: 13.64 Thickness [inches]: .013 Density Factor: .810

Treatment- Physical Type: NONE

Chemical Type: A.R.

% Ignition Loss [LOI] ---> 500°F/1 Hr: 0.17%

1150°F/1 Hr: 4.56%

% Extractable Matter: SULPHATES

Acid Alkaline [PH]: 11.38

Fabrication

Hardware: C.R.

Seaming: CHAIN Cuffing: LOCK

Sewing Thread: ECB

Ring Cover: LOCK

Fabrication Rating: GOOD

| | | 3 | | - | |
|----------------------|--|------------------|--------|--------|--------|
| PROFILE DATA | | | TOP | CENTER | воттом |
| | | As Received | 23.35 | 23.18 | 23.21 |
| Weight [oz/s | q yd] | Cleaned | 17.17 | 17.19 | 17.25 |
| | | Cleaned (Washed) | 13.63 | 13.62 | 13.68 |
| Permeability | | As received | 2.09 | 2.15 | 2.18 |
| CFM/sq ft | | Cleaned | 6.9 | 7.2 | 7.2 |
| @ .5" H2O | | Cleaned (Washed) | 49.1 | 48.3 | 44.9 |
| Breaking | Warp/Leng | th | 420 | 427 | 419 |
| Strength lbs/inch | Filling/W | idth | 223 | 224 | 220 |
| Breaking | Warp/Leng | th | 30.46% | 29.31% | 30.63% |
| Strength % Loss | Filling/W | idth | 36.10% | 35.82% | 36.96% |
| Mullen Burst | (lbs/sq i | nch) | 519 | 527 | 515 |
| Mullen Burst | % Loss | | 36.94% | 35.97% | 37.42% |
| Flex Cycles | | Warp | 23496 | 24171 | 23215 |
| [MIT Method] | | Fill | 1795 | 1847 | 1812 |
| Flex Cycles | 1987 - The Control of | Warp | 53.01% | 51.66% | 53.57% |
| Loss | | Fill | 51.46% | 50.05% | 51.00% |
| Other Testin | ā | | | | |



Date: 9-25-91

TLN: 9128

Page:

dentification: 1-B-2-R-16

Fiber Content: ECDE

Fabric Construction: WOVEN Weave: 3 X 1 TWILL Count: 44 X 24

Yarn System- Warp/Length: 37-1/0F Filling Width: 75-1/2T+75-1/0F

Avg. Weight [oz/sq yd]: 13.60 Thickness [inches]: .014 Density Factor: .750

Treatment- Physical Type: NONE Chemical Type: A.R.

% Ignition Loss [LOI] ---> 500°F/1 Hr: 0.07% 1150°F/1 Hr: 4.08%

% Extractable Matter: SULPHATES

Acid Alkaline [PH]: 11.42

Fabrication

Seaming: CHAIN Hardware: C.R.
Cuffing: LOCK Sewing Thread: ECB
Ring Cover: LOCK Fabrication Rating: GOOD

| PROFILE DATA | | ' | TOP | CENTER | BOTTOM |
|----------------------|----------|------------------|--------|--------|--------|
| | | As Received | 23.11 | 23.10 | 23.01 |
| Weight [oz/s | q yd] | Cleaned | 17.23 | 17.09 | 16.94 |
| | | Cleaned (Washed) | 13.61 | 13.57 | 13.62 |
| Permeability | | As received | 2.11 | 2.18 | 2.30 |
| CFM/sq ft | | Cleaned | 7.2 | 7.4 | 7.9 |
| @ .5" H2O | | Cleaned (Washed) | 45.9 | 46.8 | 46.0 |
| Breaking | Warp/Len | gth | 401 | 402 | 379 |
| Strength lbs/inch | Filling/ | Width | 221 | 228 | 219 |
| Breaking | Warp/Len | gth | 33.61% | 33.44% | 37.25% |
| Strength % Loss | Filling/ | Width | 36.68% | 34.67% | 37.25% |
| Mullen Burst | (lbs/sq | inch) | 509 | 510 | 497 |
| Mullen Burst | % Loss | | 38.15% | 38.03% | 39.61% |
| Flex Cycles | | Warp | 21419 | 21593 | 21174 |
| [MIT Method] | | Fill | 1689 | 1695 | 1652 |
| Flex Cycles | Warp | | 57.16% | 56.81% | 57.65% |
| Loss Fill | | 54.33% | 54.16% | 55.33% | |
| Other Testin | g | | | | |



Date: 9-25-91

TLN: 9128

Page:

dentification: 2-A-2-G-1

Fiber Content: ECDE

Fabric Construction: WOVEN Weave: 3 X 1 TWILL Count: 44 X 24

Yarn System- Warp/Length: 37-1/0F Filling Width: 75-1/2T+75-1/0F

Avg. Weight [oz/sq yd]: 13.70 Thickness [inches]: .014 Density Factor: .750

Treatment- Physical Type: NONE

Chemical Type: A.R.

% Ignition Loss [LOI] ---> 500°F/1 Hr: 0.17% 1150°F/1 Hr: 4.29%

% Extractable Matter: SULPHATES

Acid Alkaline [PH]: 11.40

Fabrication

Hardware: C.R.

Seaming: CHAIN Cuffing: LOCK

Sewing Thread: ECB

Ring Cover: LOCK

Fabrication Rating: GOOD

| | | 3 | | - | |
|----------------------------|---------------------------------------|------------------|--------|--------|--------|
| PROFILE DATA | | | TOP | CENTER | BOTTOM |
| | | As Received | 24.51 | 24.30 | 24.29 |
| Weight [oz/s | q yd] | Cleaned | 18.15 | 18.08 | 17.94 |
| | | Cleaned (Washed) | 13.68 | 13.72 | 13.71 |
| Permeability | | As received | 1.81 | 2.01 | 2.05 |
| CFM/sq ft | | Cleaned | 6.8 | 6.9 | 7.1 |
| @ .5" H2O Cleaned (Washed) | | | 48.5 | 47.1 | 47.8 |
| Breaking | Warp/Len | gth | 466 | 470 | 467 |
| Strength lbs/inch | Filling/ | Width | 270 | 273 | 268 |
| Breaking | Warp/Length | | 22.85% | 22.19% | 22.68% |
| Strength % Loss | Filling/Width | | 22.64% | 21.78% | 23.21% |
| Mullen Burst | (lbs/sq | inch) | 558 | 563 | 554 |
| Mullen Burst | % Loss | 1 | 32.20% | 31.59% | 32.69% |
| Flex Cycles | · · · · · · · · · · · · · · · · · · · | Warp | 25712 | 25808 | 25507 |
| [MIT Method] | | Fill | 1830 | 1826 | 1804 |
| Flex Cycles | - | Warp | 48.58% | 48.38% | 48.99% |
| Loss | | Fill | 50.57% | 50.62% | 51.24% |
| Other Testin | g | | | | |



Date: 9-25-91

TLN: 9128

Page:

dentification: 2-B-2-J-11

Fiber Content: ECDE

Fabric Construction: WOVEN Weave: 3 X 1 TWILL Count: 43 X 24

Yarn System- Warp/Length: 37-1/0F Filling Width: 75-1/2T+75-1/0F

Avg. Weight [oz/sq yd]: 13.68 Thickness [inches]: .013 Density Factor: .754

Treatment- Physical Type: NONE

Chemical Type: A.R.

% Ignition Loss [LOI] ---> 500°F/1 Hr: 0.24% 1150°F/1 Hr: 4.64%

% Extractable Matter: SULPHATES

Acid Alkaline [PH]: 11.47

Fabrication

Hardware: C.R.

Seaming: CHAIN Cuffing: LOCK

Sewing Thread: ECB

Ring Cover: LOCK Fabrication Rating: GOOD

| PROFILE DATA | | TOP | CENTER | BOTTOM |
|------------------|------------------|--------|--------|--------|
| | As Received | 22.89 | 23.01 | 23.06 |
| Weight [oz/sq ye | d] Cleaned | 17.01 | 16.87 | 17.12 |
| | Cleaned (Washed) | 13.69 | 31.70 | 13.65 |
| Permeability | As received | 2.35 | 2.31 | 2.29 |
| CFM/sq ft | Cleaned | 7.6 | 7.9 | 7.4 |
| @ .5" H2O | Cleaned (Washed) | 51.6 | 51.4 | 54.7 |
| | rp/Length | 471 | 472 | 468 |
| Strength Fix | lling/Width | 271 | 273 | 264 |
| | rp/Length | 22.02% | 21.85% | 22.52% |
| Strength Fil | lling/Width | 22.41% | 21.78% | 24.36% |
| Mullen Burst (1) | os/sq inch) | 550 | 561 | 542 |
| Mullen Burst % | Loss | 33.09% | 31.75% | 34.06% |
| Flex Cycles | Warp | 25605 | 25463 | 25051 |
| [MIT Method] | Fill | 1883 | 1905 | 1871 |
| Flex Cycles | Warp | 48.79% | 49.07% | 49.90% |
| & Loss | Fill | 49.08% | 48.49% | 49.41% |
| Other Testing | : | | | |



Date: 9-25-91

TLN: 9128

Page:

dentification: 2-B-4-020

Fiber Content: ECDE

Fabric Construction: WOVEN

Weave: 3 X 1 TWILL Count: 44 X 24

Yarn System- Warp/Length: 37-1/0F

Filling Width: 75-1/2T+75-1/0F

Avg. Weight [oz/sq yd]: 13.80 Thickness [inches]: .014 Density Factor: .754

Treatment- Physical Type: NONE

Chemical Type: A.R.

% Ignition Loss [LOI] ---> 500°F/1 Hr: 0.19%

1150°F/1 Hr: 4.89%

% Extractable Matter: SULPHATES

Acid Alkaline [PH]: 11.41

Fabrication

Seaming: CHAIN

Hardware: C.R.

Cuffing: LOCK

Sewing Thread: ECB

Ring Cover: LOCK

Fabrication Rating: GOOD

| | _ | 1 | | • | |
|----------------------|---------------|----------|--------|--------|--------|
| PROFILE DATA | | | TOP | CENTER | BOTTOM |
| | As Rece | eived | 24.38 | 24.26 | 24.14 |
| Weight [oz/s | q yd] Cleaned | | 18.09 | 18.02 | 17.90 |
| | Cleaned | (Washed) | 13.78 | 13.81 | 13.82 |
| Permeability | As rece | eived | 1.49 | 1.91 | 2.11 |
| CFM/sq ft | Cleaned | <u> </u> | 6.7 | 6.9 | 7.1 |
| @ .5" H2O | Cleaned | (Washed) | 45.2 | 44.7 | 45.1 |
| Breaking | Warp/Length | | 475 | 481 | 470 |
| Strength lbs/inch | Filling/Width | | 275 | 289 | 272 |
| Breaking | Warp/Length | | 21.36% | 20.36% | 22.19% |
| Strength % Loss | Filling/Width | | 21.20% | 17.19% | 22.06% |
| Mullen Burst | (lbs/sq inch) | | 561 | 563 | 559 |
| Mullen Burst | % Loss | : | 31.845 | 31.59% | 32.08% |
| Flex Cycles | Warp | | 25991 | 26136 | 25643 |
| [MIT Method] | Fill | | 1903 | 1928 | 1869 |
| Flex Cycles | Warp | | 48.02% | 47.73% | 48.71% |
| Loss | Fill | N | 48.54% | 47.86% | 49.46% |
| Other Testin | g | | | | |



Date: 9-25-91

TLN: 9128

Page:

dentification: 2-C-6-I12

Fiber Content: ECDE

Fabric Construction: WOVEN

Weave: 3 X 1 TWILL Count: 44 X 24

Yarn System- Warp/Length: 37-1/0F Filling Width: 75-1/2T+75-1/0F

Avg. Weight [oz/sq yd]: 13.65 Thickness [inches]: .014 Density Factor: .752

Treatment- Physical Type: NONE

Chemical Type: A.R.

% Ignition Loss [LOI] ---> 500°F/1 Hr: 0.14% 1150°F/1 Hr: 4.42%

% Extractable Matter: SULPHATES

Acid Alkaline [PH]: 11.38

Fabrication

Hardware: C.R.

Seaming: CHAIN Cuffing: LOCK

Sewing Thread: ECB

Ring Cover: LOCK Fabrication Rating: GOOD

| | | | | _ | |
|----------------------|----------|--|--------|--------|--------|
| PROFILE DATA | | | TOP | CENTER | BOTTOM |
| | | As Received | 24.30 | 24.01 | 24.01 |
| Weight [oz/s | q yd] | Cleaned | 17.99 | 17.79 | 17.64 |
| | | Cleaned (Washed) | 13.64 | 13.66 | 13.64 |
| Permeability | **** | As received | 1.64 | 1.93 | 2.03 |
| CFM/sq ft | | Cleaned | 6.7 | 6.9 | 7.0 |
| @ .5" H2O Clean | | Cleaned (Washed) | 52.5 | 50.8 | 51.3 |
| Breaking | Warp/Len | gth | 479 | 478 | 475 |
| Strength lbs/inch | Filling/ | Width | 283 | 290 | 281 |
| Breaking | Warp/Len | gth | 20.70% | 20.86% | 21.36% |
| Strength % Loss | Filling/ | Width | 18.91% | 16.91% | 19.48% |
| Mullen Burst | (lbs/sq | inch) | 564 | 569 | 564 |
| Mullen Burst | % Loss | | 31.47% | 30.86% | 31.47% |
| Flex Cycles | | Warp | 28815 | 29163 | 28146 |
| [MIT Method] | | Fill | 2108 | 2140 | 2079 |
| Flex Cycles | es Warp | | 42.37% | 41.67% | 43.71% |
| k Loss | oss Fill | | 42.99% | 42.14% | 43.78% |
| Other Testin | g | ······································ | | | |



Date: 9-25-91

TLN: 9128

Page:

dentification: 2-B-2-M13

Fiber Content: ECDE

Fabric Construction: WOVEN Weave: 3 X 1 TWILL Count: 44 X 24

Yarn System- Warp/Length: 37-1/0F Filling Width: 75-1/2T+75-1/0F

Avg. Weight [oz/sq yd]: 13.73 Thickness [inches]: .013 Density Factor: .752

Treatment- Physical Type: NONE

Chemical Type: A.R.

% Ignition Loss [LOI] ---> 500°F/1 Hr: 0.17% 1150°F/1 Hr: 4.29%

% Extractable Matter: SULPHATES

Acid Alkaline [PH]: 11.39

Fabrication

Hardware: C.R.

Seaming: CHAIN Cuffing: LOCK

Sewing Thread: ECB

Ring Cover: LOCK

Fabrication Rating: GOOD

| PROFILE DATA | | | TOP | CENTER | BOTTOM |
|----------------------|---------------|------------------|--------|--------|--------|
| | | As Received | 24.26 | 24.19 | 23.80 |
| Weight [oz/s | q yd] | Cleaned | 17.88 | 17.79 | 17.71 |
| | | Cleaned (Washed) | 13.75 | 13.72 | 13.71 |
| Permeability | | As received | 1.35 | 1.98 | 2.07 |
| CFM/sq ft | | Cleaned | 6.9 | 7.0 | 7.0 |
| @ .5" H2O | | Cleaned (Washed) | 48.7 | 49.1 | 49.2 |
| Breaking | Warp/Length | | 470 | 474 | 469 |
| Strength lbs/inch | Filling | /Width | 268 | 271 | 265 |
| Breaking | Warp/Le | ngth | 22.19% | 21.52% | 22.35% |
| Strength % Loss | Filling/Width | | 23.21% | 22.41% | 24.07% |
| Mullen Burst | (lbs/sq | inch) | 554 | 555 | 549 |
| Mullen Burst | % Loss | | 32.69% | 32.56% | 33.29% |
| Flex Cycles | | Warp | 25742 | 25815 | 25416 |
| [MIT Method] | | Fill | 1879 | 1894 | 1876 |
| Flex Cycles | Warp | | 48.52% | 48.37% | 49.17% |
| % Loss Fill | | 49.19% | 48.78% | 49.27% | |
| Other Testin | g | | | | |
| | _ | | | | |



Date: 9-25-91

TLN: 9128

Page:

dentification: 2-B-4-P18

Fiber Content: ECDE

Fabric Construction: WOVEN Weave: 3 X 1 TWILL Count: 43 X 24

Yarn System- Warp/Length: 37-1/0F Filling Width: 75-1/2T+75-1/0F

Avg. Weight [oz/sq yd]: 13.59 Thickness [inches]: .013 Density Factor: .807

Treatment- Physical Type: NONE

Chemical Type: A.R.

% Ignition Loss [LOI] ---> 500°F/1 Hr: 0.09% 1150°F/1 Hr: 4.15%

% Extractable Matter: SULPHATES

Acid Alkaline [PH]: 11.41

| Fabrication | Cu | aming: CHAIN ffing: LOCK ng Cover: LOCK | Hardware: C.R. Sewing Thread: ECB Fabrication Rating: GOOD | | | |
|--|------------------|---|--|--------|--------|--|
| PROFILE DATA | | | TOP | CENTER | воттом | |
| | | As Received | 24.21 | 24.05 | 23.98 | |
| Weight [oz/s | q yd] | Cleaned | 17.97 | 17.82 | 17.80 | |
| | | Cleaned (Washed) | 13.60 | 13.60 | 13.57 | |
| Permeability | 1111 | As received | 1.68 | 2.08 | 2.09 | |
| CFM/sq ft | | Cleaned | 6.9 | 7.1 | 7.0 | |
| @ .5" H2O | | Cleaned (Washed) | 55.0 | 54.5 | 54.8 | |
| Breaking Warp/Leng Strength lbs/inch Filling/W | | th | 464 | 468 | 460 | |
| | | idth | 267 | 267 | 262 | |
| Breaking | Warp/Leng | Warp/Length | | 22.52% | 23.84% | |
| Strength % Loss | Filling/Width | | 23.50% | 23.50% | 24.93% | |
| Mullen Burst | (lbs/sq i | nch) | 550 | 551 | 548 | |
| Mullen Burst | % Loss | 1- 1- 1- 1- 1- 1- 1- 1- 1- 1- 1- 1- 1- 1 | 33.17% | 33.05% | 33.41% | |
| Flex Cycles | | Warp | 25536 | 25708 | 25429 | |
| [MIT Method] | | Fill | 1876 | 1900 | 1817 | |
| Flex Cycles | Flex Cycles Warp | | 48.93% | 48.58% | 49.14% | |
| % Loss | | Fill | 49.27% | 48.62% | 50.87% | |
| Other Testin | g | | | | | |



Date: 9-25-91

TLN: 9128

Page:

dentification: 2-A-101-E-1

Fiber Content: ECDE

Fabric Construction: WOVEN Weave: 3 X 1 TWILL Count: 44 X 24

Yarn System- Warp/Length: 37-1/0F Filling Width: 75-1/2T+75-1/0F

Avg. Weight [oz/sq yd]: 13.68 Thickness [inches]: .013 Density Factor: .812

Treatment- Physical Type: NONE Chemical Type: A.R.

% Ignition Loss [LOI] ---> 500°F/1 Hr: 0.09% 1150°F/1 Hr: 4.62%

% Extractable Matter: SULPHATES

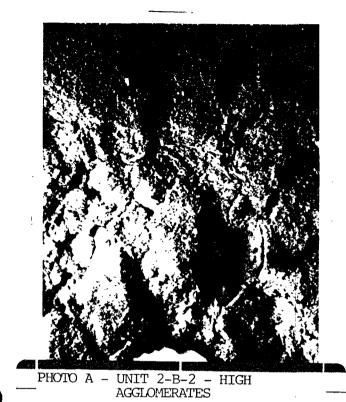
Acid Alkaline [PH]: 11.41

Fabrication

Seaming: CHAIN
Cuffing: LOCK
Ring Cover: LOCK
Hardware: C.R.
Sewing Thread: ECB
Fabrication Rating: GOOD

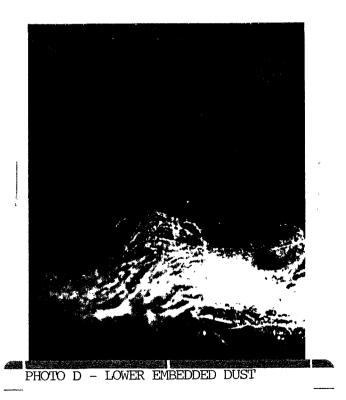
| PROFILE DATA | * * | | TOP | CENTER | воттом |
|----------------------|---------------|------------------|--------|--------|--------|
| | | As Received | 24.39 | 24.21 | 24.12 |
| Weight [oz/s | q yd] | Cleaned | 18.01 | 17.95 | 17.84 |
| | | Cleaned (Washed) | 13.67 | 13.68 | 13.68 |
| Permeability | | As received | 1.90 | 1.94 | 2.05 |
| CFM/sq ft | | Cleaned | 7.0 | 7.0 | 7.2 |
| @ .5" H2O | | Cleaned (Washed) | 43.5 | 44.1 | 43.4 |
| Breaking | Warp/Length | | 473 | 480 | 471 |
| Strength lbs/inch | Filling/Width | | 265 | 265 | 263 |
| Breaking | Warp/Length | | 21.69% | 20.53% | 22.02% |
| Strength % Loss | Filling/Width | | 24.07% | 24.07% | 24.64% |
| Mullen Burst | (lbs/sq i | nch) | 561 | 568 | 557 |
| Mullen Burst | % Loss | | 31.84% | 30.98% | 32.32% |
| Flex Cycles | | Warp | 25843 | 26100 | 25549 |
| [MIT Method] | | Fill | 1905 | 1921 | 1847 |
| Flex Cycles | Cycles Warp | | 48.31% | 47.80% | 48.90% |
| % Loss Fill | | | 48.49% | 48.05% | 50.05% |
| Other Testin | g | | | | |





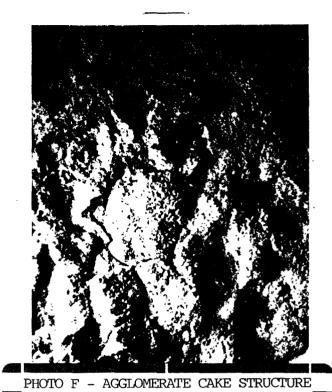
















Grubb Filtration Testing Services, Inc.

8006 Route 130 North Post Office Box 1156 Delran, N.J. 08075

(609) 461-1800 Fax (609) 461-1613

Laboratory Report No. 955 Date: December 3, 1991

PREPARED FOR:

Intermountain Power Service Corp.

850 West Brush Wellman Road

Delta, UT 84624-9546

REFERENCE:

Units #1 and #2 Used Filter Bag Analysis

Purchase Order No. 92-47917

BACKGROUND

Intermountain Power Service Corp. (IPSC) operates two GEESI reverse-gas fabric filters serving two identical 840 MW coal-fired boilers, Unit #1 and Unit #2. Each fabric filter consists of three separate casings with sixteen compartments per casing, each containing 396 filter bags, for a total of 19,008 bags per unit. The bags are 12.0" diameter by 32' 11-11/16" long (under 75 lbs. tension) with cap top, compression band bottom, and eight anti-collapse rings. They are fabricated from 13.5 oz/yd 2 glass fabric with Burlington Glass Fabrics' (now BGF Industries') I-625 acid-resistant finish, warp face out.

It has been well-documented that different versions of I-625 finish were utilized for each of the two units, due to a change made by BGF in the interim. Unit #1 bag fabric was finished with the original I-625 finish which is light gray in color and yields a more supple fabric hand. Unit #2 bag fabric was finished with a revised I-625 finish which is darker brownish-gray in color and yields a somewhat stiffer fabric hand. These finishes are referred to hereinafter as "light" (Unit #1) and "dark" (Unit #2).

Startup (initial flue gas) and commercial operation dates for the two baghouses were as follows:

| <u>Unit #</u> | Startup Date | Commercial Operation |
|---------------|--------------|----------------------|
| 1 | 3/28/86 | June 1986 |
| 2 | 2/16/87 | May - June 1987 |

A total of eleven (11) bags were submitted for analysis. Four (4) bags were removed from Unit #1 on July 25, 1991. Three of these were original equipment bags after an installed service life of 64 months, and one (as noted below) was a replacement bag which had been installed for only nine months.

Of the seven (7) bags submitted from Unit #2, four were original equipment bags which had been removed on either July 15, 1991 (Casing B) or July 26, 1991 (Casings A&C) after an installed service life of fifty-three months. Two were original equipment bags which had been removed from casing B in February 1991, after forty-eight months of installed service, prior to the initial operation of sonic horns in compartment B2. One bag, removed on July 26, 1991, was supposed to be a replacement with only sixteen months of installed service, but the age of this bag remains uncertain.

Information regarding the location from which each sample bag was removed, its fabric finish type, and its service history is given in the following table.

| Unit # | Casing/ Comp. # | Thimble #_ | Finish Type | | talled Life months |
|--------|--------------------|------------|----------------|----|-----------------------|
| | | | | | |
| 1 | A1 | F1 | Light | 64 | |
| 1 | В2 | R15 | Dark | 9 | (Note a.) |
| 1 | B10 | N20 | Light | 64 | |
| 1 | C6 | B12 | Light | 64 | |
| | | | | | |
| 2 | A1 | D1 | Light | 53 | (Note b.) |
| 2 | A7 | F1 | Light | 16 | (Note c.) |
| 2 | B2 | 110 | Dark | 48 | (Note d.) |
| 2 | В2 | P15 | Dark | 53 | (Note e.) |
| 2 | В4 | 14 | Dark | 48 | (Note f.) |
| 2 | В4 | 18 | Dark | 53 | |
| 2 | С6 | N12 | Dark | 53 | |
| | | | | | |

NOTES

- a. Replacement bag installed on October 15, 1990; rusty cap and drip stains (resulting from an in-leakage source known to IPSC) were to be ignored and avoided for the purpose of this test per IPSC instructions.
- b. Reportedly an original Unit #2 bag, although the fabric finish was the type used in Unit #1.
- c. Supposed to have been a replacement bag installed April 5, 1990 (Bag D1 or E1), but IPSC records show that bag F1 (an original equipment bag) was removed, and thus the age of this bag is uncertain.
- d. Removed in February 1991; "Before Horns".
- e. Bag immediately adjacent to a sonic horn; after four to five months of sonic horn operation.
- f. Removed in February 1991.

IPSC requested that the used bags be evaluated and tested to determine their general condition and fabric strength retention compared to the new values obtained during the original fabric quality assurance/quality control (QA/QC) testing program and to values obtained on the used bags previously tested by GFTS (Report No. 683) in 1990. In particular, IPSC was interested in determining what differences may exist between used bags from the two units that might account for the higher operating pressure drop in Unit #2 (vs. Unit #1), and in the effects of sonic horn operation on the bags in Unit #2, Compartment B2.

SUMMARY

These bags had not changed significantly during the twelve to seventeen months of operation since the previous set of bags was tested. Fabric strength (Mullen Burst and MIT Flex) and permeability values were nearly identical to those of previously tested bags for each of the two finish types. Average bag weights were 18% lower than before (31 lb. vs. 38 lb.) on the Unit #1 bags and 23% higher than before (43 lb. vs. 35 lb.) on the Unit #2 bags, but these weights may reflect differences in operation just prior to bag removal or differences in removal procedures rather than any permanent change in the residual dust mass.

Based on the stability in physical properties which the bags have exhibited over the past seventeen months of operation, an ultimate bag life of <u>perhaps</u> eight-to-ten years (double their current life), or even longer, might be anticipated. This speculative estimate of potential bag life presumes the continuation of current operating conditions and does not take into account any intolerable pressure drop situation which might precipitate a decision by IPSC to replace the bags.

The sonic horns which are being tested in Unit #2, compartment B2, have had no apparent effect on the bags, based on laboratory analysis of the samples submitted. The as-received fabric permeability of the bag (P15) from the sonic horn compartment (B2) was 1.42 cfm compared to the average of 1.40 cfm for all fabric with the same (dark) finish. The weight of this bag was 34 lb. compared to a weight of 34.5 lb. for the bag (I8) removed on the same day (July 15, 1991) from a compartment without sonic horns (B4) in the same unit. Both of these bags had significantly lower weights than the bags removed from Unit #2 on other dates, which ranged from 41 1b. to 50.5 lb. A more extensive "in situ" bag weighing program would be required to evaluate the effect of sonic horns on the residual dust mass in the bags. Relative flow measurements, as recommended in GFTS Report No. 683, would be required to evaluate the effects of sonic horns on filter drag (ΔP/filtration velocity). No adverse effect on fabric strength was evident on the bag, which had been located immediately adjacent to one of the horns, after four to five months of sonic horn operation.

FABRIC STRENGTH and PHYSICAL CONDITION OF THE BAGS

All of the used bags except two were in excellent physical condition with no signs of service related wear. The reverse-gas collapse folds were moderate to light in intensity, and no "accordion-type" creases were evident in the bottom sections indicating that adequate bag tension had been maintained. The bag from Unit #1, Compartment B2, had severe rust stains on its cap and in its top section. As previously stated, IPSC was already aware of an in-leakage problem which results in condensation and corrosion in the area above this bag.

The bag from Unit #2, Compartment A7, exhibited several worn or failed areas. The third through the seventh ring covers (from the bottom) were worn through, exposing the rings, in a vertical alignment. There were two horizontal holes approximately 3 inches long, one each located 1-2 inches above the sixth and seventh ring covers; however, these holes were not in vertical alignment with the worn ring covers. This bag also had an externally darkened area, approximately one foot in diameter, in its bottom section. This bag (F1) was located along the front wall of the compartment in an area where other bag failures (D1 and E1) have occurred. Perhaps there is a problem with clearance between this bag and the wall (or loose insulation?), or maybe it was damaged by exposure to an adjacent failed bag. IPSC should investigate the cause of isolated bag failures in this area, if they haven't already.

Fabric strength values were remarkably high for glass bags which have been in service for 48-64 months. This is undoubtedly due in part to the low baghouse operating temperature, $275^{\circ}F$ outlet, and to the alkaline fly ash (used fabric pH = 11.3) which have moderated the effects of acidic flue gas on the acid-resistant finished glass fabric.

Only a slight decrease in the average Mullen Burst strength had occurred during the seventeen months of operation since the previous set of bags was tested; 5% on the "light" finished fabric and 11% on the "dark" finished fabric. Based on the net Mullen Burst strengths, the average value for each bag exceeded the 550 psi minimum specification for new fabric, with an overall average reduction of 15% compared to the reported new fabric QC values. Based on the gross Mullen Burst strength values, which were 50 psi greater than the net values, the strength loss would be only 9%. It was not stated for either the fabric specification or for the QC data whether gross or net Mullen Burst values were used.

Lower Mullen Burst values were obtained on the "light" finished used fabric compared to the "dark" finished used fabric, which corresponded to the strength differential reported for the new fabric with the two finish types. The "dark" finished bag which had been in service for only nine months in Unit #1 (B2) exhibited somewhat higher strength than the Unit #2 bags, with the same type of finish, which had been in service for 48-53 months. Refer to Tables 1-A, 1-B, and 2 for Mullen Burst strength data. All bags exhibited uniform strength along their length (top, middle, and bottom sections tested), with each section varying by <10% from the mean for the entire bag.

Although the used fabric exhibited a significant reduction (42-67%) in MIT Flex values compared to new fabric, no additional loss in MIT Flex had occurred during the 12-17 months of operation since bags were tested in 1990, and the magnitude of these values is still quite high for used glass bags. The average warp MIT value for all except one of the used bags tested exceeded the 8000 cycle minimum specification for new fabric, and the average fill MIT value for all except one of the used bags exceeded the 2000 cycle minimum specification for new fabric. Both finish types had comparable used fabric warp MIT values, but the "light" finished fabric had approximately 50% lower fill MIT values than the "dark" finished fabric, which again is reflective of the new fabric values obtained on the two finish types. The "dark" finished bag which had been in service for only nine months in Unit #1 (B2) exhibited significantly higher MIT flex values than the 48-53 month old Unit #2 bags. Refer to Tables 1-A, 1-B, and 3 for MIT Flex data.

Glass bag failures in low-sulfur-coal fired utility boiler baghouses are nearly always related to some phenomenon which results in localized fabric damage or degradation, rather than to a general loss in fabric strength. Examples of such phenomena are bag fabrication defects, damage during installation, loss of adequate bag tension, ambient air inleakage, expansion ring corrosion, dust impingement abrasion, etc. The importance of used fabric strength in determining the ultimate service life of glass filter bags is likely related to the extent to which stronger fabric is more resistant to these localized wear phenomena. Although GFTS has no data base on Intermountain Power's specific fabric/finish combination, Teflon B finished fabrics have been observed to provide continuing filter bag service life with Mullen burst values in the 200-300 psi range and with fill MIT flex values of <100 cycles.

FABRIC PERMEABILITY AND BAGHOUSE PRESSURE DROP

The most significant difference observed between the Unit #1 and Unit #2 used bags, and in particular between the "light" and "dark" finished bag fabrics, was in the as-received (dirty) permeabilities. As shown in Table 4, the average permeability of Unit #1 "light" finished bags was 2.25 cfm, 61% higher than the Unit #2 "dark" finished bag average of 1.40 cfm, although Unit #1 has an additional year of service. The "dark" finished replacement bag, which had been in service only nine months in Unit #1 (B2), had a dirty permeability of only 1.41 cfm, comparable to the values obtained on this finished fabric with 48-53 months service in Unit #2. However, the "light" finished bags in Unit #2 (A1 and A7), whose exact origins are unknown though they are believed to be original bags, exhibited an average dirty permeability of 1.58 cfm, comparable to the other Unit #2 (dark finished) bags rather than to the other "light" finished (Unit #1) bags.

The Unit #1 bags had an average "as-received" weight of 31 lb. (29 lb. if the "dark" bag is excluded) compared to the average Unit #2 bag weight of 43 lb. Once the loose dust (dislodged during bag removal, packing, and shipping) was poured off, there were no apparent differences in the residual dust cake appearance among the bags regardless of which unit they had been in or which finish type they were. The dust cake was not heavy, and no crust or nodulation was evident. The dust could be readily vacuumed off the inside surface of the bags, and the average vacuumed fabric permeability values were comparable for both units, as shown in Table 5. Vacuumed permeability values in the 20 cfm range for woven glass fabrics are indicative of "normal", minimal penetration of ash into the fabric structure.

Since the bags are subjected to much greater movement during removal, shipment, and sample preparation than they are during in service cleaning, the actual in situ fabric permeability is always somewhat less than that measured in the laboratory. It can be assumed, however, that the bags from both units were handled similarly resulting in the dislodgement of comparable quantities of residual ash.

It thus appears that the dirty fabric permeability values and bag weights correlate in a relative sense with the operating pressure drop of the two fabric filters. However, the permeability data does not provide conclusive proof that the difference in pressure drop between the two units is related to differences in fabric finish, "light" vs. "dark", although it does imply such a correlation. Any differences in startup procedures and operating conditions between the two units (boilers and baghouses) should be evaluated by IPSC as potential causes of the difference in pressure drop between the two baghouses.

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The filter drag, which is the pressure drop divided by the filtration velocity (air-to-cloth ratio), of an operating filter bag consists of two components: the drag resulting from freshly collected ash during the filtration cycle and the residual drag resulting from the permanent residual ash cake on the fabric. The residual drag has also been demonstrated to consist of two components: the drag resulting from the fabric itself and dust imbedded within the fabric structure, and the drag resulting from the permanent residual dust cake which accumulates on the inside bag surface but not in direct contact with the fabric surface.

Sonic horns are frequently utilized, either as original or retrofit equipment, in utility boiler baghouses to supplement reverse-gas cleaning and reduce operating pressure drop. They are particularly effective at reducing the quantity of residual ash which can often continue to increase during the life of the bags, especially with highly cohesive fly ashes. In GFTS Report No. 683 (page 6), it was stated that, considering the Intermountain Power ash characteristics and residual ash loadings reported by Southern Research Institute, "it is not certain that sonic horns would necessarily provide the significant reduction in bag weights and pressure drop that they have in other utility boiler baghouses", and that "it is unlikely that the sonic horns will have any effect on the 'as-received' fabric permeability which is believed to be related to the dust/fabric interface component of residual drag, but they may reduce the residual drag by decreasing the residual dust loading." The absence of any effect of the sonic horns on "as-received" fabric permeability was demonstrated by this testing, but the overall effectiveness of sonic horns at reducing the residual dust loading and filter drag (ΔP) must ultimately be determined by controlled measurements of bag weights and relative gas flow in both the sonic-horn-equipped and control compartments.

FABRIC CONSTRUCTION AND PROPERTIES

Washed samples of each fabric were analyzed for construction, L.O.I., and permeability. This data is summarized and compared to original QC data and to the specification in Tables 1-A and 1-B, and presented for each individual bag in Table 7. All bag fabrics met the count and weight specifications. All fabric L.O.I. values were within the range reported for new fabric of the same finish type. Average permeability values were approximately 20% higher than the range reported for new fabric, but this is not abnormal considering the handling which the fabric experiences during bag fabrication, packing, installation, in-service use, removal, and washing (though performed carefully).

TABLE 1-A

INTERMOUNTAIN POWER USED BAGS - 1991

USED FABRIC PROPERTIES vs. NEW FABRIC QC DATA

(Testing performed on washed samples, except Mullen and MIT on vacuumed samples)

"LIGHT" FINISH (GE 1-625)

| FABRIC | | QC DATA USED BAG DAT | | | | | TA | | |
|---|--|----------------------------|---------------------------|--------------------------|-------------------------|--------------------------|-----------------------|--|--|
| <u>PROPERTY</u> | SPECIFICATION | | MAX | <u>AVG</u> | MIN | <u>MAX</u> | % CHANGE* | | |
| Loss On Ignition: | 4.0 min. | 4.5 | 5.7 | 5.16 | 4.75 | 5.60 | + 1% | | |
| Permeability: (cfm/ft2) | 35-55 | 36.2 | 54.0 | 56.6 | 47.3 | 65.8 | + 25% | | |
| Mullen Burst: (psi**) | 550 min. | 565 | 821 | 580 | 551 | 607 | - 16% | | |
| MIT Flex (cycles): Warp - Fill - Weight: (oz/yd2) | 8,000 min. 2,000 min. 13.5 <u>+</u> 5% | 17,000 2,860 Not Rep | 41,000 5,830 ported | 11,300 2,540 13.65 | 7,570 2,000 13.24 | 13,100 2,860 13.88 | - 61% - 42% N/A | | |
| Count (per inch): Warp - Fill - | 44 ± 2 24 ± 2 | Not Rep Not Rep | | 43 24 | 43 24 | 43 24 | N/A N/A | | |

All used bag fabric samples had a 3x1 Twill (left hand) weave, ECDE 37 1/0 warp yarns, and ECDE 75 1/3 (2 texturized and 1 filament) fill yarns, as specified.

 $[\]ast$ % Change compared to the average of the minimum and maximum QC values. Mean QC data were not reported.

^{**} Used bag Mullen Burst values are "net" (gross-tare; where tare = 50 psi). The specification and QC Mullen Burst values were not specified whether "net" or "gross".

TABLE 1-B INTERMOUNTAIN POWER USED BAGS - 1991 USED FABRIC PROPERTIES vs. NEW FABRIC QC DATA

(Testing performed on washed samples, except Mullen and MIT on vacuumed samples)

"DARK" FINISH (I-625 G)

| FABRIC | | QC I | ATA | | USED | BAG DATA | |
|---------------------------------------|--------------------------|--------------------|------------------|--------------------------|--------------------------|--------------------------|-----------------------|
| PROPERTY | SPECIFICATION | | <u>MAX</u> | <u>AVG</u> | MIN | <u>MAX</u> | % CHANGE* |
| Loss On Ignition: | 4.0 min. | 4.6 | 5.6 | 4.93 | 4.68 | 5.30 | - 3% |
| Permeability: (cfm/ft ²) | 35-55 | 41.8 | 49.6 | 55.0 | 48.6 | 57.4 | + 20% |
| Mullen Burst: (psi**) | 550 min. | 757 | 901 | 702 | 685 | 733 | - 15% |
| MIT Flex (cycles): Warp - Fill - | 8,000 min. 2,000 min. | 36,000 9,639 | 41,000 10,905 | 12,800 3,780 13.67 | 10,400 3,170 13.61 | 16,700 4,890 13.83 | - 67% - 63% N/A |
| Weight: (oz/yd ²) | 13.5 ± 5% | Not Rep | orted | 13.67 | 13.01 | 13.63 | N/A |
| Count (per inch): Warp - Fill - | 44 ± 2 24 ± 2 | Not Rep Not Rep | | 43 24 | 43 24 | 43 24 | N/A N/A |

All used bag fabric samples had a 3x1 Twill (left hand) weave, ECDE 37 1/0 warp yarns, and ECDE 75 1/3 (2 texturized and 1 filament) fill yarns, as specified.

- * % Change compared to the average of the minimum and maximum QC values. Mean QC data were not reported.
- ** Used bag Mullen Burst values are "net" (gross-tare; where tare = 50 psi). The specification and QC Mullen Burst values were not specified whether "net" or "gross".

 ${\hbox{{\tt NOTE}}}\colon$ The Mullen Burst and MIT Flex averages ${\hbox{{\tt exclude}}}$ the data obtained on the replacement bag with only nine months service.

TABLE 2 INTERMOUNTAIN POWER USED BAGS - 1991

MULLEN BURST PROFILE (psi, net)

Vacuumed Samples

| | | | BAG SECTION | | BAG |
|-----------------------|--------------------------|-----|-------------|---------------|----------------|
| <u>UNIT</u> | <u>COMP.</u> | TOP | MIDDLE | <u>BOTTOM</u> | <u>AVERAGE</u> |
| 1 | A1 | 615 | 538 | 583 | 579 |
| 1 | B2* | | 732 | 767 | 750 |
| 1 | В10 | 587 | 547 | 522 | 552 |
| 1 | C6 | 560 | 525 | 568 | 551 |
| UNIT 1 AVO | G. ng bag 1B2) | 587 | 537 | 558 | 560 |
| 2 | A1** | 630 | 617 | 583 | 610 |
| 2 | A7*** | 658 | 573 | 590 | 607 |
| 2 | B2 (Bag I10) | 728 | 698 | 688 | 705 |
| 2 | B2 (Bag P15) | 692 | 677 | 693 | 687 |
| 2 | B4 (Bag I4) | 722 | 697 | 635 | 685 |
| 2 | B4 (Bag I8) | 735 | 737 | 728 | 733 |
| 2 | C6 | 720 | 685 | 688 | 698 |
| UNIT 2 AV | G. | 698 | 669 | 663 | 675 |
| "LIGHT" F | INISH AVG. | 610 | 560 | 570 | 580 |
| "DARK" FI (excludi | NISH AVG. ng bag 1B2) | 719 | 699 | 686 | 702 |

^{* &}quot;Dark" finish; replacement bag - 9 months service; top not tested ** "Light" finish; reportedly an original bag

The value for each bag section is an average of 3 tests.

^{*** &}quot;Light" finish; replacement bag ?

TABLE 3 INTERMOUNTAIN POWER USED BAGS - 1991

MIT FLEX DATA (cycles to failure)

(.03" head; 4 1b weight; #8 spring; values corrected to 55% R.H.)

Vacuumed Middle Sections

| <u>UNIT</u> | COMP. | WARP | $\underline{\mathtt{FILL}}$ |
|-------------|-----------------------------|--------|-----------------------------|
| 1 | A1 | 7,570 | 2,860 |
| 1 | B2* | 20,600 | 7,340 |
| 1 | B10 | 10,300 | 2,000 |
| 1 | C6 | 13,000 | 2,830 |
| UNIT 1 AVG. | (excluding bag 1B2) | 10,300 | 2,560 |
| 2 | A1** | 12,700 | 2,360 |
| 2 | A7*** | 13,100 | 2,660 |
| 2 | B2 (Bag I10) | 11,400 | 3,680 |
| 2 | B2 (Bag P15) | 10,400 | 3,580 |
| 2 | B2 (Bag I4) | 12,000 | 3,170 |
| 2 | B4 (Bag I8) | 13,700 | 3,560 |
| 2 | C6 | 16,700 | 4,890 |
| UNIT 2 AVG. | | 12,900 | 3,410 |
| "LIGHT" FIN | IISH AVG. | 11,300 | 2,540 |
| "DARK" FINI | SH AVG. (excluding bag 1B2) | 12,800 | 3,780 |

 $[\]star$ "Dark" finish; replacement bag - 9 months service $\star\star$ "Light" finish; reportedly an original bag

Each warp MIT value is an average of 3 specimens tested, and each fill is an average of 6 specimens tested.

^{*** &}quot;Light" finish; replacement bag ?

TABLE 4 INTERMOUNTAIN POWER USED BAGS - 1991 "AS RECEIVED" PERMEABILITY PROFILE $(cfm/ft^2 @ 0.5 WG)$

| | j | | BAG SECTION | N | BAG |
|-----------------|-----------------|--------------|--------------|--------------|--------------|
| UNIT | COMP. | TOP | MIDDLE | BOTTOM | AVERAGE |
| 1 | A1 | 2.08 | 1.98 | 2.89 | 2.32 |
| 1 | B2* | | 1.72 | 1.09 | 1.41 |
| 1 | B10 | 2.18 | 2.24 | 2.95 | 2.46 |
| 1 | C6 | 1.87 | 1.41 | 2.60 | 1.96 |
| UNIT 1 AVO | | 2.04 2.04 | 1.84 1.88 | 2.38 2.81 | 2.09 2.25 |
| 2 | A1** | 1.39 | 1.80 | 1.51 | 1.57 |
| 2 | A7*** | 1.77 | 1.41 | 1.56 | 1.58 |
| 2 | B2 (Bag I10) | 1.39 | 1.25 | 2.14 | 1.59 |
| 2 | B2 (Bag P15) | 1.65 | 1.28 | 1.33 | 1.42 |
| 2 | B4 (Bag I4) | 1.58 | 1.23 | 1.22 | 1.34 |
| 2 | B4 (Bag I8) | 1.45 | 1.11 | 1.57 | 1.38 |
| 2 | C6 | 1.18 | 1.05 | 1.55 | 1.26 |
| UNIT 2 AV | G.: | | | | |
| All Ba "Dark | ags " Bags | 1.49 1.45 | 1.30 1.18 | 1.55 1.56 | 1.45 |
| "LIGHT" F | INISH AVG. | 1.86 | 1.77 | 2.30 | 1.98 |
| "DARK" FII | NISH AVG. | 1.45 | 1.27 | 1.48 | 1.40 |

 $[\]star$ "Dark" finish; replacement bag - 9 months service; top not tested $\star\star$ "Light" finish; reportedly an original bag

The value for each bag section is an average of 3 tests.

^{*** &}quot;Light" finish; replacement bag ?

TABLE 5 INTERMOUNTAIN POWER USED BAGS - 1991

 $(cfm/ft^2 @ 0.5" WG)$

VACUUMED PERMEABILITY PROFILE

| | | | BAG SECTION | V | BAG |
|------------|-----------------|------|-------------|--------|---------|
| UNIT | COMP. | TOP | MIDDLE | BOTTOM | AVERAGE |
| 1 | A1 | 28.9 | 28.1 | 24.9 | 27.3 |
| 1 | В2* | | 18.6 | 14.7 | 16.7 |
| 1 | В10 | 17.9 | 21.7 | 21.2 | 20.3 |
| 1 | C6 | 25.1 | 32.4 | 28.2 | 28.6 |
| UNIT 1 AVO | Ĵ. | 24.0 | 25.2 | 22.2 | 23.8 |
| 2 | A1** | 26.5 | 28.6 | 17.7 | 24.3 |
| 2 | A7*** | 24.8 | 24.6 | 18.0 | 22.5 |
| 2 | B2 (Bag I10) | 19.7 | 23.3 | 16.8 | 19.9 |
| 2 | B2 (Bag P15) | 26.2 | 22.8 | 17.4 | 22.1 |
| 2 | B4 (Bag I4) | 22.9 | 22.4 | 14.5 | 19.9 |
| 2 | B4 (Bag I8) | 19.3 | 17.4 | 16.0 | 17.6 |
| 2 | C6 | 22.7 | 22.9 | 23.4 | 23.0 |
| UNIT 2 AVO | G. | 23.2 | 23.1 | 17.7 | 21.3 |
| "LIGHT" F | INISH AVG. | 24.6 | 27.1 | 22.0 | 24.6 |
| "DARK" FI | NISH AVG. | 22.2 | 21.2 | 17.1 | 19.9 |

^{* &}quot;Dark" finish; replacement bag - 9 months service
** "Light" finish; reportedly an original bag

The value for each bag section is an average of 3 tests.

^{*** &}quot;Light" finish; replacement bag ?

TABLE 6
INTERMOUNTAIN POWER USED BAGS - 1991
MISCELLANEOUS TEST DATA

| <u>UNIT</u> | COMP. | BAG WEIGHT (1b) "AS RECEIVED" | BAG LENGTH(1) | FABRIC pH(2) |
|-------------|--------------------------------|-------------------------------|---------------|--------------|
| 1 | A1 | 28.5 | 32' 10" | 11.27 |
| 1 | B2* | 37.5 | 32' 9-3/8" | 11.53 |
| 1 | B10 | 30 | 32′8" | 10.87 |
| 1 | C6 | 27.5 | 32' 8-3/4" | 11.22 |
| UNIT 1 AVG. | | 31 | 32' 9" | 11.22 |
| 2 | A1** | 48 | 32' 10-1/4" | 11.12 |
| 2 | A7*** | 41 | 32' 9-3/4" | 11.49 |
| 2 | B2 (Bag I10) | 50.5 | 32' 10" | 11.63 |
| 2 | B2 (Bag P15 |) 34 | 32' 9-3/4" | 11.43 |
| 2 | B4 (Bag I4) | 47.5 | 32' 10-1/2" | 11.29 |
| 2 | B4 (Bag I8) | 34.5 | 32' 10-1/4" | 11.27 |
| 2 | С6 | 45 | 32' 10-1/4" | 11.32 |
| UNIT 2 AVG. | (all bags) | 43 | 32' 10-1/8" | 11.38 |
| | moved 2/91 | 49 | | |
| _ | moved 7/15/91 moved 7/26/91 | 34 45 | | |

⁽¹⁾ Measured at the seam under firm hand tension

^{(2) 5} g as-received fabric per 100 ml distilled water

^{* &}quot;Dark" finish; replacement bag - 8 months service

^{** &}quot;Light" finish; reportedly an original bag

^{*** &}quot;Light" finish; replacement bag ?

TABLE 7

INTERMOUNTAIN POWER USED BAGS - 1991

FABRIC PROPERTIES - WASHED SAMPLES

| UNIT | COMP. | COUNT - WxF (per inch) | WEIGHT (oz/yd ²) | PERMEABILITY (cfm/ft ²) | L.O.I. <u>(%)</u> |
|---------|-----------------|------------------------|---------------------------------|-------------------------------------|----------------------|
| 1 | A1 | 43 x 24 | 13.24 | 65.8 | 4.98 |
| 1 | B10 | 43 x 24 | 13.76 | 47.3 | 4.75 |
| 1 | C6 | 43 x 24 | 13.74 | 54.7 | 5.60 |
| 2 | A1 | 43 x 24 | 13.61 | 61.7 | 5.25 |
| 2 | A7 | 43 x 24 | 13.88 | 53.4 | 5.21 |
| "LIGHT" | FINISH AVG | 43 X 24 | 13.65 | 56.6 | 5.16 |
| 2 | B2 (Bag I10) | 43 x 24 | 13.62 | 56.6 | 4.84 |
| 2 | B2 (Bag P15) | 43 x 24 | 13.65 | 53.1 | 4.72 |
| 2 | B4 (Bag I4) | 43 x 24 | 13.64 | 57.4 | 4.68 |
| 2 | B4 (Bag I8) | 43 x 24 | 13.83 | 48.6 | 4.75 |
| 2 | C6 | 43 x 24 | 13.61 | 56.9 | 5.28 |
| 1 | В2 | 43 x 24 | 13.67 | 57.1 | 5.30 |
| "DARK" | FINISH AVG | 43 x 24 | 13.67 | 55.0 | 4.93 |

All samples had the same weave and nominal yarns sizes, as follows:

Weave:

3x1 Left-Hand Twill

Warp Yarns:

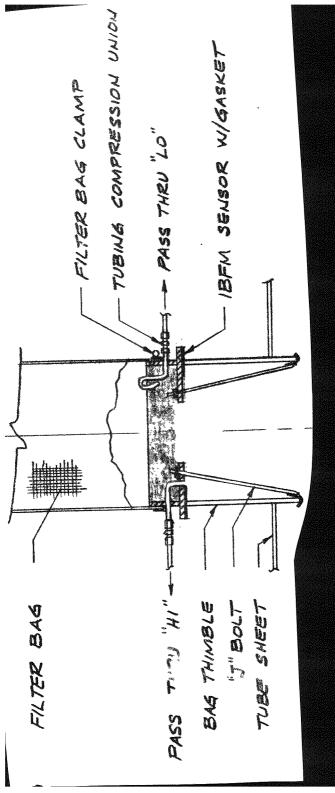
ECDE 37 1/0

Fill Yarns:

ECDE 75 1/3 (2 texturized + 1 filament)



IP12_001254



IP12_001255

Response 12

Phil Hailes

Pulverizers

Office Black Notebook "Pulverizer Studies, Uprates, Upgrades"

Binar wats

Printed out for: PHIL-H

- 24-Jan-05 16:21:06

0 Messages U2 Pulv / U2 Pulv Operating data

24-Jan-05 16:21:06

| Unit 2 (951.3 MW) | Paiv A | The state of the s | Pulv C | Palv 0 | FRIV 5 | Pulv F | Pulv G | Walton Hi |
|--------------------|---------|--|--------|--------|--------|--------|--------|-----------|
| Coal Flow389.0TPL | i) 57.1 | 57.5 | 57.E | 55.6 | 54.9 | 54.6 | 54.3 | Badi |
| Feeder Speed | 83.3 | 83.3 | 84.0 | 82.6 | 79.6 | 78.6 | 79.3 | Calc |
| Amps (Duct Pr57.1) | 58.6 | 63.4 | 61.1 | 62.9 | 70.1 | 66.8 | 63.6 | 0.0 |
| Coal Pipe Vel | 4709. | 4691. | 4673. | 4759. | 4661. | 4655. | 4808. | 0. |
| PA Flow % | 97.5 | 96.2 | 97.8 | 97.8 | 96.0 | 97.3 | 99.1 | 0.0 |
| (PA: damper Pos | 80.5 | 66.3 | 69.6 | 72.9 | 71.1 | 70.6 | 72.2 | 0.0 |
| SA Damper Pos | 79.8 | 79.7 | 81.4 | 83.6 | 81.3 | 79.5 | 75.2 | 35.0 |
| PA Mass Flow | 3846. | 3811. | 3831. | 3874. | 3778. | 3832. | 3915. | 0. |
| Pulv DP (NOx 0.30 | 18.5 | 19.1 |)14.8 | 16.9 | 18.0 | 22.8 | 19.0 | 0.0 |
| Air to Fuel Ratio | 2.03 | 2.01 | 2.00 | 2.07 | 2.09 | 2.14 | 2.18 | Calc |
| Pulv Inlet Temp | 372.5 | 383.9 | 345.0 | 373.1 | 366.8 | 398.8 | 415.5 | 74.9 |
| Pulv Outlet Temp | 149.9 | 153.0 | 144.8 | 150.8 | 153.4 | 144.1 | 150.6 | 76.7 |
| Coal Bias | 0.0 | 0.0 | -2.9 | 0.0 | -2.9 | -4.3 | -4.3 | 0.0 |
| Air Bias | 3.3 | 3.6 | 6.0 | 4.6 | 3.6 | 6.3 | 7.5 | 0.0 |
| Hyd Skid Pr Fdbk | 2281. | 2341. | 2473. | 2353. | 1708. | 2408. | 2465. | 0. |
| Hyd Skid Pr Setpt | t 2400. | 2400. | 2400. | 2400. | 2400. | 2390. | 2388. | 1149. |

EndTim= 24-Jan-05 16:21:06 /EvalTim= 24-Jan-05 16:21:06 /PanRate= 0

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O Messages U2 Pulv U2 Pulv Operating data

24-Jan-05 16:16:43

| Unit 2 950.8 MW | | MINT H | Pulv C | PULV D | eulv v | Pulv F | Pulv G | |
|--------------------|---------|--------|--------|--------|--------|--------|--------|-------|
| Coal Flow391.3TP | I 57.0 | 56.9 | 58.8 | 57.1 | 56.3 | 54.8 | 54.7 | Badī |
| Feeder Speed | 84.3 | 84.9 | 86.1 | 84.4 | 82.6 | 79.3 | 80.2 | Calc |
| Amps (Duct Pr56.7 | 58.8 | 63.2 | 60.9 | 63.1 | 71.3 | 68.1 | 63.7 | 0.0 |
| Coal Pipe Vel | 4730. | 4718. | 4706. | 4762. | 4688. | 4677. | 4815. | 0. |
| PA Flow % | 97.4 | 96.7 | 97.4 | 97.6 | 95.8 | 97.1 | 98.8 | 0.0 |
| (PAdamper Pos | 80.8 | 66.5 | 70.4 | 73.8 | 71.5 | 71.4 | 72.4 | 0.0 |
| SA Damper Pos | 80.3 | 80.1 | 82.0 | 84.3 | 81.7 | 80.3 | 76.1 | 35.0 |
| PA Mass Flow | 3861. | 3829. | 3872. | 3864. | 3803. | 3870. | 3938. | 0. |
| Pulv DP (NOx 0.30) | 18.7 | 19.5 | 15.6 | 17.8 | 18.6 | 22.7 | 19.1 | 0.0 |
| Air to Fuel Ratio | 0 2.01 | 1.99 | 1.98 | 2.03 | 2.03 | 2.14 | 2.15 | Calc |
| Pulv Inlet Temp | 372.8 | 382.4 | 346.2 | 372.8 | 366.5 | 398.7 | 414.9 | 74.6 |
| Pulv Outlet Temp | 150.1 | 152.6 | 144.4 | 150.8 | 153.0 | 144.1 | 150.1 | 76.7 |
| Coal Bias | 0.0 | 0.0 | -2.9 | 0.0 | -2.9 | -4.3 | -4.3 | 0.0 |
| Air Bias | 3.3 | 3.6 | 6.0 | 4.6 | 3.6 | 6.3 | 7.5 | 0.0 |
| Hyd Skid Pr Fdbk | 2279. | 2341. | 2473. | 2355. | 1708. | 2408. | 2464. | 0. |
| Hyd Skid Pr Setp | t 2400. | 2400. | 2400. | 2400. | 2400. | 2390. | 2397. | 1149. |

EndTim= 24-Jan-05 16:16:43 /EvalTim= 24-Jan-05 16:16:43 /PanRate= 0

Printed out for: PHIL-H - 24-Jan-05 14:30:30

O Messages U2 Pulv U2 Pulv Operating data

24-Jan-05 14:30:30

| Unit 2 952.5 MW | Pulv A | | Pulv C | Fulv o | PU 57 19 | Pulv F | Pulv G | Poly H |
|--------------------|---------|-------|--------|--------|----------|--------|--------|--------|
| Coal Figw393.1TP | I 56.8 | 57.5 | 58.9 | 57.0 | 56.2 | 54.3 | 55.1 | Badl |
| Feeder Speed | 85.0 | 84.7 | 85.9 | 84.2 | 82.9 | 79.8 | 80.5 | Calc |
| Amps (Duct Pr57.0) | 58.8 | 63.8 | 63.0 | 65.4 | 70.5 | 67.7 | 63.8 | 0.0 |
| Coal Pipe Vel | 4749. | 4720. | 4724. | 4762. | 4690. | 4691. | 4838. | 0. |
| PA Flow % | 97.8 | 96.8 | 97.8 | 98.2 | 96.2 | 97.5 | 99.6 | 0.0 |
| (PAdamper Pos | 80.8 | 66.8 | 70.6 | 74.3 | 71.6 | 71.2 | 72.3 | 0.0 |
| SA Damper Pos | 81.2 | 81.2 | 82.6 | 84.9 | 82.5 | 81.5 | 76.9 | 35.0 |
| PA Mass Flow | 3856. | 3821. | 3875. | 3882. | 3816. | 3861. | 3936. | 0. |
| Pulv DP(NOx 0.3Q | 19.1 | 19.8 | 16.5 | 17.5 | 18.0 | 22.5 | 19.1 | 0.0 |
| Air to Fuel Ratio | 0 2.01 | 1.99 | 1.99 | 2.02 | 2.04 | 2.13 | 2.16 | Calc |
| Pulv Inlet Temp | 371.7 | 383.9 | 347.8 | 376.1 | 363.7 | 400.7 | 418.0 | 74.8 |
| Pulv Outlet Temp | 150.1 | 152.6 | 144.6 | 150.4 | 151.4 | 144.2 | 150.6 | 76.7 |
| Coal Bias | 0.0 | 0.0 | -2.9 | 0.0 | -2.9 | -4.3 | -4.3 | 0.0 |
| Air Bias | 3.3 | 3.6 | 6.0 | 4.6 | 3.6 | 6.3 | 7.5 | 0.0 |
| Hyd Skid Pr Fdbk | 2279. | 2342. | 2472. | 2355. | 1691. | 2406. | 2464. | 0. |
| Hyd Skid Pr Setp | t 2400. | 2400. | 2400. | 2400. | 2400. | 2400. | 2400. | 1149. |

EndTim= 24-Jan-05 14:30:30 /EvalTim= 24-Jan-05 14:30:30 /PanRate= 0

From:

Phil Hailes

To:

Aaron Nissen; Bill Morgan; Conf 1; Dean Wood; Garry Christensen; Jerry Finlinson;

Jon Christensen; Ken Nielson; Phil Hailes

Date:

1/20/2005

Time:

1:00:00 PM - 3:00:00 PM

Subject:

Rescheduled....Primary Air for Pulverizers

Place:

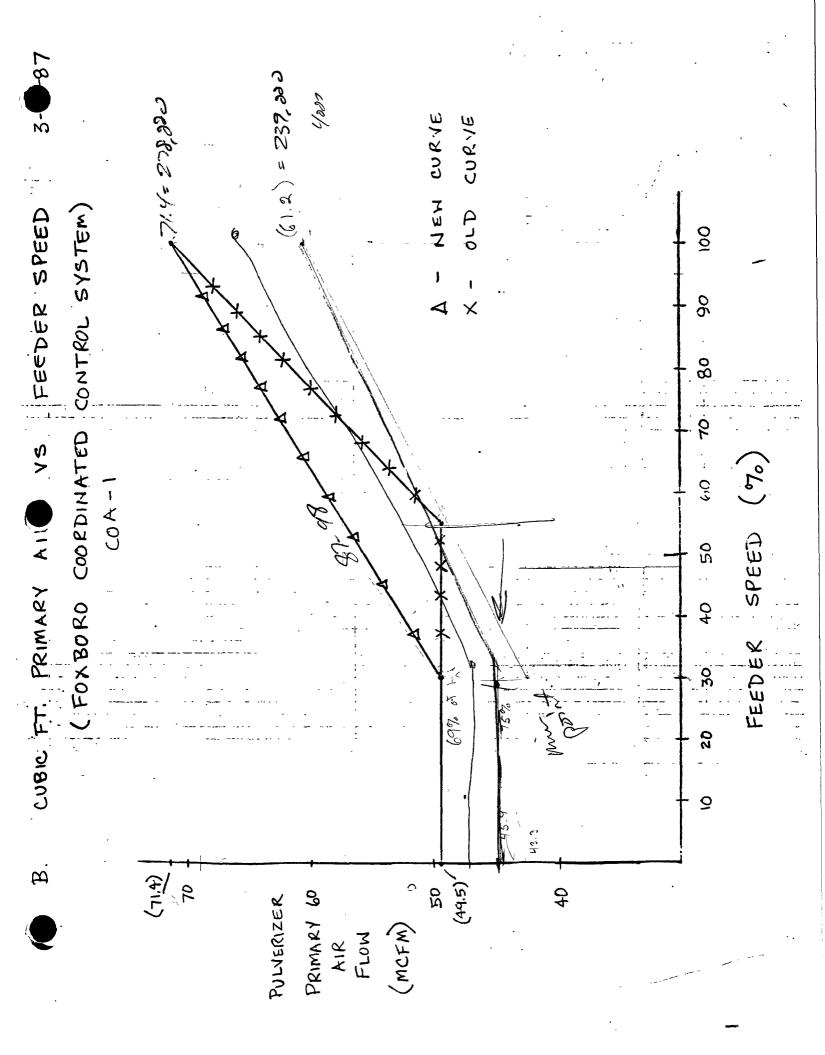
The intent of this meeting is to discuss the status of PA flow controls, measurements, etc for the pulverizers. There is much discussion about the PA settings, coal line velocities, damper positions and their effect on pulverizer performance. There exists a perception that something is wrong with the controls and setups.

Items:

- 1) What is the correct PA flow to set?
- 2) What effect does this set-up have on the mill performance?
- 3) What is the correct air curve to have?
- 4) Should we fine-tune each individual mill with appropriate PA flow and coal line velocity, etc.

CC:

Jerry Hintze



8 4 W Actual,

1917 - 1998 239,000 278,000

21hage (2)

14 \(2)

278,000

2003

All Mid (259,000)

2003 PU VIII 259,000 2004 All Uniz 237,100

2004 Summer - Complaints begin.

Uni 2 237, 20- => 100%

Muro

- History 278 (1987-1898) - 2003

-82 W Univer Recommended.

2 Tier lave system. Rotaling vs. Stalinary.
-All mills have some curve.
- Curve plots.

MEMORANDUM

INTERMOUNTAIN POWER SERVICE CORPORATION

TO:

George W. Cross

Page <u>1</u> of <u>1</u>

FROM:

Dennis K. Killian

DATE:

January 10, 2005

SUBJECT:

Pulverizer Primary Air Flow Rescale

We request that the airflow on the Pulverizer Primary Air be increased from the present 239 KLBH, to 265 KLBH for full scale. Operations has indicated that the primary air is being biased up on all the pulverizers and the primary air duct pressure is being set higher due to the coal quality over the last few months.

The original full scale primary air of 289 KLBH was decreased after testing was completed with B&W. The testing showed that coal line velocities could be maintained at a lower maximum primary airflow.

This change would allow the Operators to reduce the present normal bias on primary airflow and also give them additional primary airflow range when the coal quality drops on an intermittent basis.

Please approve this change with your signature below.

Contact Bill Morgan, extension 6462, with questions or comments.

George W. Cross

President & Chief Operations Officer

Date

BRM/JKH:jmj

cc: Jon Finlinson

Stan Smith

Printed out for: PHIL-H - 24-Jan-05 07:16:27

O Messages U2 Pulv U2 Pulv Operating data

24-Jan-05 07:16:27

| Unit 2 871.5 MW | English /- | | Pulv C | Datitat D | | Pulv F | Pulv G | |
|--------------------|------------|-------|--------|-----------|-------|--------|--------|-------|
| Coal Flow364.3TPF | I 55.9 | | 55.8 | 55.8 | 54.1 | 50.4 | 52.9 | Badī |
| Feeder Speed | 84.1 | 82.0 | 83.6 | 81.8 | 78.6 | 76.9 | 77.4 | Calc |
| Amps (Duct Pr56.7) | 57.0 | 61.3 | 61.3 | 60.9 | 66.6 | 66.8 | 64.4 | 0.0 |
| Coal Pipe Vel | 4622. | 4567. | 4586. | 4593. | 4562. | 4558. | 4679. | 0. |
| PA Flow % | 96.5 | 95.3 | 96.4 | 95.9 | 95.2 | 96.2 | 98.2 | 0.0 |
| (PAdamper Pos | 78.2 | 64.8 | 68.5 | 72.1 | 69.7 | 71.2 | 70.9 | 0.0 |
| SA Damper Pos | 77.9 | 77.3 | 78.9 | 81.8 | 78.8 | 77.0 | 72.6 | 35.0 |
| PA Mass Flow | 3815. | 3771. | 3815. | 3778. | 3763. | 3810. | 3884. | 0. |
| Pulv DP (NOx 0.3C) | 16.2 | 18.0 | 15.4 | 15.1 | 16.3 | 24.1 | 17.1 | 0.0 |
| Air to Fuel Ratio | 1.98 | 2.00 | 1.99 | 2.02 | 2.08 | 2.15 | 2.18 | Calc |
| Pulv Inlet Temp | 365.4 | 373.9 | 338.2 | 357.4 | 368.7 | 384.2 | 399.2 | 72.3 |
| Pulv Outlet Temp | 148.9 | 152.8 | 144.4 | 150.6 | 152.3 | 143.4 | 149.7 | 77.5 |
| Coal Bias | 0.0 | 0.0 | -2.9 | 0.0 | -2.9 | -4.3 | -4.3 | 0.0 |
| Air Bias | 3.3 | 3.6 | 6.0 | 4.6 | 3.6 | 6.3 | 7.5 | 0.0 |
| Hyd Skid Pr Fdbk | 2285. | 2352. | 2472. | 2351. | 1700. | 2307. | 2437. | 0. |
| Hyd Skid Pr Setp | t 2400. | 2400. | 2400. | 2400. | 2381. | 2360. | 2356. | 1149. |

EndTim= 24-Jan-05 07:16:27 /EvalTim= 24-Jan-05 07:16:27 /PanRate= 0

Printed out for: PHIL-H - 24-Jan-05 07:32:01

O Messages U2 Pulv U2 Pulv Operating data

24-Jan-05 07:32:01

| Unit 2 906.3 MW | Dig. or L | 1202147 64 | Pulv C | J-113 5 7 13 | Page B | Pulv F | Pulv G | Puin H |
|--------------------|-----------|------------|--------|--------------|--------|--------|--------|--------|
| Coal Flow386.1TPF | I 5/.1 | 37. | 58.8 | y and y | 56.2 | 54.3 | 54.7 | PadI |
| Feeder Speed | 85.3 | 87.5 | 88.0 | 85.7 | 83.3 | 81.2 | 83.2 | Calc |
| Amps (Duct Pr57.2) | 57.3 | 62.0 | 62.4 | 63.2 | 65.2 | 68.9 | 63.2 | 0.0 |
| Coal Pipe Vel | 4728. | 4723. | 4722. | 4732. | 4667. | 4703. | 4829. | 0. |
| PA Flow & | 98.1 | 97.1 | 98.4 | 98.3 | 96.6 | 97.9 | 99.7 | 0.0 |
| (PAdamper Pos | 79.8 | 66.4 | 69.8 | 73.8 | 71.1 | 73.2 | 72.5 | 0.0 |
| SA Damper Pos | 81.2 | 81.5 | 82.8 | 85.5 | 83.1 | 81.7 | 77.1 | 35.0 |
| PA Mass Flow | 3886. | 3830. | 3902. | 3894. | 3835. | 3876. | 3955. | 0. |
| Pulv DP (NOx 0.3C) | 18.2 | 18.7 | 16.0 | 16.3 | 18.0 | 25.4 | 19.4 | 0.0 |
| Air to Fuel Ratio | 2.00 | 1.93 | 1.95 | 1.99 | 2.02 | 2.10 | 2.09 | Calc |
| Pulv Inlet Temp | 378.0 | 387.7 | 351.0 | 369.6 | 365.6 | 394.9 | 415.6 | 72.4 |
| Pulv Outlet Temp | 148.8 | 152.3 | 143.9 | 150.1 | 149.4 | 143.4 | 150.1 | 77.5 |
| Coal Bias | 0.0 | 0.0 | -2.9 | 0.0 | -2.9 | -4.3 | -4.3 | 0.0 |
| Air Bias | 3.3 | 3.6 | 6.0 | 4.6 | 3.6 | 6.3 | 7.5 | 0.0 |
| Hyd Skid Pr Fdbk | 2272. | 2354. | 2472. | 2346. | 1701. | 2357. | 2454. | 0. |
| Hyd Skid Pr Setp | 2400. | 2400. | 2400. | 2400. | 2400. | 2396. | 2400. | 1149. |

EndTim= 24-Jan-05 07:32:01 /EvalTim= 24-Jan-05 07:32:01 /PanRate= 0

From:

Phil Hailes

To:

Aaron Nissen: Alan Dewsnup: Conf 5: Dean Wood: Garry Christensen: Jerry Hintze:

Jon Finlinson; Kelly Cloward: Phil Hailes: Richard Schmit: Stan Smith: Will Lovell

Date:

1/12/2005

Time:

2:00:00 PM - 3:30:00 PM

Subject:

Pulv Team Meeting, Long-Term Future of Pulverizers

Place:

Will and I have decided the general agenda for the upcoming pulverizer meeting. I'll ask some of you beforehand, to get some information together for this meeting. We would like to discuss the future requirements of the mills considering the present operating criteria. Coal flow has been >410 TPH, duct pressure has been as high as 60", with full PA flow and air bias to the mills. I'll develop more details for the agenda next week, but for now the general agenda is expected to be:

- 1) Is present operation indicative of long-term future operation requirments? What is the future coal quality to be? Have the mills met expectations considering this operation?
- If major improvements in performance are required of the mills what are the options? How mu money will be available? Consider variations of the following options:

a) "Upsize" existing mills.

b) Replace a few of the existing mills with larger mills.

c) Install additional mills.

- Mahtenance Anny Outages Run with 8 mills. - BEW Classifler, Static Aum Jobble

Installation plan for the large B&W throats that have been selected.

Uprige.
L+ \$685,000 /mill

#9,000,000 /station

\$4500,000/unt

New Milk BAW 89 68 Tons/h (136,000 16./h) MILE

24 89 68 Tons/hr (136,000 16/hr)

98 84 Tons/hr (168,000 16/hr) 249, \$1,500,000/mill

\$24,000,000/sta 4m

4D 1103 96 Tons/hr (192,000/s/hr) 419 \$1,340,000/mill

\$21,440,000/stakkn

Alston

\$ 225,000/ silve Rotation Classifier for Abe /

IP12 001266

From:

<rory.eastman@power.alstom.com>

To:

<phil-h@ipsc.com>
1/14/2005 12:28:57 PM

Date: Subject:

Mill cost

Phil.

To replace B&W MPS 89G mills for increased capacity we would select an Alstom HP1103. When equipped with a static classifier this mill has a nominal capacity of 192,200LB/HR based on 70% -200 mesh fineness and a 55 HGI coal. The mills are design and manufactured in the USA so we have the flexibility to minimize site changes required to match existing interface points.

The present day price for one complete mill including planetary gearbox, independent lube system and 1000HP drive motor would be Approximately \$1,340,000, (One Million Three Hundred and Forty Thousand dollars).

Attached is some descriptive information of the basic design features of the HP mill.

(See attached file: HP Mill Brochure.pdf)

As I had mentioned the <u>dynamic classifier</u> is another good consideration for your application. Depending on the existing operational parameters of your mills and your upgrade requirements a 10% throughput increase can be achieved by retrofitting these classifiers. Attached is some basic descriptive information and reference list for the Alstom Dynamic classifier.

(See attached file: Dynamic Classifier Users List.xls)(See attached file: Application of the ALSTOM Dynamic Classifier to Coal Pulverizers - TIS 8701.pdf)

We appreciate the opportunity to support you in your initial consideration of mill replacements and or additions.

Please feel free to call on us for any additional information you may need.

Thank You,

Rory Eastman Alstom Power Milling Systems Manager

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CC:

<stanley.kmiotek@power.alstom.com>

Richard Stait Quality

Jersy Hintye Positife funding. \$125 mul/hr. Zyr payback.

\$ 100,000 /mo/ en derake.

\$ 25 (3,137 mm+) \$1,200,000 = \$80,000 => ala Desenip. 26 5314 Myn. H)

- Throat Schoolule

The Hailes - Primary Chi - Meet e Gekeduled. - Cure Story Coal Anchity
2124 % Ash. for the future.

HOTH the same.

Rock

\$ 100,000 derate / month.

Dercte Info

Tuesday, December 21, 2004
9:00 a.m., Conference Room #4

INTERMOUNTAIN POWER SERVICE CORPORATION Monthly Staff and Supervisors' Meeting

AGENDA

| ī. | Training "Christmas Wish List" | MRM |
|------|---|-----|
| II. | Supervisor's Safety Bulletin "Brrr! It's Cold Outside!" | MRM |
| III. | Converter Station Monthly Production Report | TBS |
| IV. | Personnel Employment Statistical Report | RWS |
| V. | Incentive Program | DKK |
| VI. | Monthly Production Report | GKH |
| acs | | |

SUPERVISING

SARTY Communicating For A Common Soal



INTERHOUNTAIN POWER SERVICE CORPORATION

by Mike Mooney

Brrri III s Cold Outside!

don't know about you, but I've been downright cold this winter. Is this a sign that the drought is over and that winters are returning to "normal?" Who knows at this time? All I can advise employees and their families to do for now is to deal with the cold temperatures that we are presently facing.

The following is taken from the BLR's December issue of "OSHA Required Training for Supervisors." Review this information and pass it on to your employees.



Cold temperatures and severe weather in winter can be dangerous to your safety and health if you're not adequately prepared to deal with them. Whether you're driving on icy roads, walking along slippery sidewalks, shoveling snow, working or playing outdoors, or just staying home stoking your fireplace, you need to know what the hazards of winter are and how to protect your safety and health in cold and harsh weather.

Dealing with cold temperatures

Especially for employees who work outdoors, keeping warm and dry during cold and severe weather is essential. But it's important for those who enjoy outdoor winter recreation as well. Really, everyone should know how to keep safe in severe weather and cold temperatures because you never know when you'll be caught outside or stranded in your vehicle under hostile weather conditions.

Frostbit can develop quickly

One of the most common hazards associated with exposure to extreme cold temperatures is frostbite.

 Body parts most often affected are the nose, ears, cheeks, fingers, and toes. Skin may appear white and feel hard to the touch, but soft underneath. It is important to get protection for the body at the stage of these early symptoms.

- More serious symptoms include an uncomfortably cold feeling, then numbness, which may be accompanied by tingling, aching, or a brief pain. Skin darkens, looks grayish, and can blister.
- Severe frostbite can cause permanent tissue damage and loss of movement.

Another common winter hazard - hypothermia

- Hypothermia occurs when a person's body temperature gets dangerously low.
- Windy conditions, physical exhaustion, and wet clothing increase the risk of hypothermia.
- Hypothermia can occur even when temperatures are not that cold.
- Symptoms include cold and shivering followed by pain in the extremities and also numbness, stiffness, poor coordination, drowsiness, slow or irregular breathing and heart rate, slurred speech, cool skin, and puffiness in the face.

Risk factors

Several factors can increase your risk of frostbite and hypothermia.

- Use of alcohol before going outside
- Blood vessel diseases
- Diabetes
- Prior frostbite

Protect yourself

- Dress in layers of loose dry clothes cotton, silk, or wool underneath, and an outer layer of waterproof and wind-resistant material.
- Cover hands, feet, face, and head. Body heat is lost mainly through the head, so a hat is vital
- Keep moving when out in the cold.
- Whether people are working or playing outdoors in cold weather, it's important that they take regular breaks in a warm place.









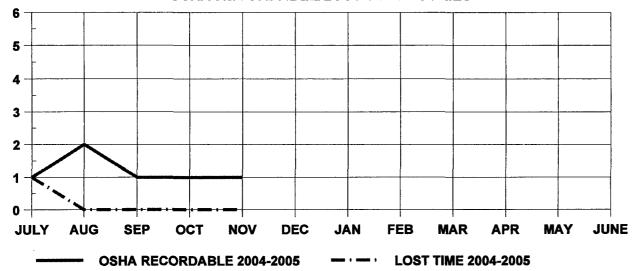






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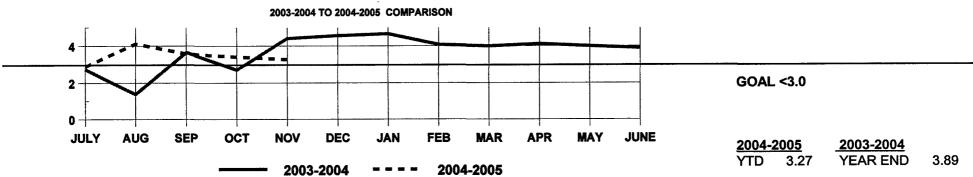
OSHA RECORDABLE/LOST TIME INJURIES



| OSHA | 2004-2005 | 2003-2004 |
|-----------|------------------|------------------|
| MONTH | 1 | MONTH 4 |
| YTD | 6 | YEAR END 18 |
| LOST TIME | <u>2004-2005</u> | <u>2004-2005</u> |
| MONTH | 0 | MONTH 1 |
| YTD | 1 | YEAR END 4 |

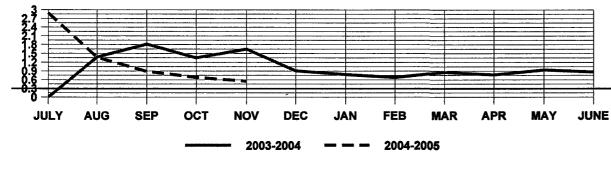
2-

OSHA RECORDABLE INCIDENT RATE









GOAL < 0.3

2004-2005

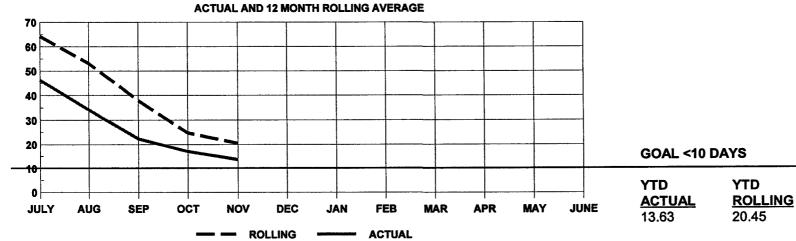
2003-2004

YTD 0.55

YEAR END 0.87

4

SEVERITY INDEX



DAYS AWAY FROM WORK PER 200,000 HOURS WORKED

November 20



INTERMOUNTAIN CONVERTER STATION

MONTHLY EVENT REPORT November, 2004

| | | <u>Month</u> | | Year to Date | |
|-----|---|--------------|-----|--------------|-----|
| 1. | DC Transmission Availability (one or both poles on) | 100.00 | % | 100.00 | % |
| 2. | Bipole Availability (both poles on) | 100.00 | % | 100.00 | % |
| 3. | Pole 1 Availability | 100.00 | % | 100.00 | % |
| 4. | Pole 2 Availability | 100.00 | % | 100.00 | % |
| 5. | AC Transmission Availability (Mona 1&2, Gonder - any or all on) | 100,00 | % | 100.00 | % |
| 6. | Mona 1 Availability | 100.00 | % | 99.98 | % |
| 7. | Mona 2 Availability | 100.00 | % | 100.00 | % |
| 8. | Gonder Availbility | 100.00 | % | 98.84 | % |
| 9. | DC Transmission Energy Capacity Factor | | | | |
| | Actual Transmitted Pole 1 MWH | 635,038.00 | MWH | 3,231,322.00 | MWH |
| | Actual Transmitted Pole 2 MWH | 638,390.00 | MWH | 3,251,123.00 | MWH |
| | Actual Transmitted Bipole MWH | 1,273,428.00 | MWH | 6,482,445.00 | MWH |
| | Total Possible MWH | 1,382,400.00 | MWH | 7,052,160.00 | MWH |
| | STS Utilization | 92.12 | % | 91.92 | % |
| 10. | DC Transmission Capability Loss | | | | |
| | Total Capacity Loss | 0.00 | MWH | 0.00 | MWH |
| | Maximum MWH Capability | 1,382,400.00 | MWH | 7,052,160.00 | MWH |
| | Total MWH Capability Loss (%) | 0.00 | % | 0.00 | % |
| 11. | ICS Incentive Availability | | | 100.00 | % |

SOUTHERN TRANSMISSION SYSTEM

| POLE | 1 | | 2.5 | | * | | And the second | * * |
|-------|---------|------|--------------------------|------------|-------------------------------|--------------------------------|---------------------------------------|---------------------------------|
| | DATE | TIME | DESCRIPTION | EVENT TYPE | OUTAGE DURATION (Hours) | CAPABILITY LOSS (MW Net) | MAX. AVAIL. CAPACITY POLE / STS | TOTAL CAPACITY LOSS (MWH) |
| Begin | | | No Outages for November. | None | 0.00 | 0 | 960/1920 | 0.00 |
| End | | | | | | | | |
| POLE | 1 TOTAL | _S | | 0 | 0.00 | //// | | 0.00 |

| POLE | 2 | | | | | ٠, | | |
|-------|--------|---------|--------------------------|------------|-------------------------------|--------------------------------|---------------------------------------|---------------------------------|
| , | DATE | TIME | DESCRIPTION | EVENT TYPE | OUTAGE DURATION (Hours) | CAPABILITY LOSS (MW Net) | MAX. AVAIL. CAPACITY POLE / STS | TOTAL CAPACITY LOSS (MWH) |
| Begin | | | No Outages for November. | None | 0.00 | 0 | 960/1920 | 0.00 |
| End | | | | | | | | |
| POLE | 2 TOTA | LS | | 0 | 0.00 | //// | | 0.00 |
| STS | TOTALS | | | 0 | 0.00 | | //// | 0.00 |

AC TRANSMISSION SYSTEMS

| Mona | 1 | | , , , , | | | 1 | * 7, 2 | ÷, , | 3.55 | |
|-------|--------|------|-------------------------|-----|------------|-------------------------------|--------------------------------|------|------|---------------------------------|
| | DATE | TIME | DESCRIPTION | · | EVENT TYPE | OUTAGE DURATION (Hours) | CAPABILITY LOSS (MW Net) | · | | TOTAL CAPACITY LOSS (MWH) |
| Begin | | | No Outages for November | er. | None | 0.00 | О | 1// | | 0.00 |
| End | | | | | | | | | | |
| MONA | 1 TOTA | LS | | | 0 | 0.00 | /// | /// | // | 0.00 |

| Mona | 2 | | , | | | | na k | | - 14 | | 7. |
|----------------------|---------|------|-------------------|---------------|---|------------|-------------------------------|--------------------------------|------|-----|---------------------------------|
| , 19 , 19 , 19 | DATE | TIME | DESCRIPTION | 56 57 7 | Š | EVENT TYPE | OUTAGE DURATION (Hours) | CAPABILITY LOSS (MW Net) | | | TOTAL CAPACITY LOSS (MWH) |
| Begin | | | No Outages for No | ovember. | | None | 0.00 | 0 | | /// | 0.00 |
| End | | | | | | | | | | /// | 1 |
| MONA | 2 TOTAL | .s | | | | 0 | 0.00 | //// | | /// | 0.00 |

| Gond | er | ` ` ` | | * * * * * * * * * * * * * * * * * * * | ^- | | , ,, | | , , , , | |
|-------|---------|-------|--------------------------|---------------------------------------|------------|-------------------------------|--------------------------------|-----|---------|---------------------------------|
| | DATE | TIME | DESCRIPTION | | EVENT TYPE | OUTAGE DURATION (Hours) | CAPABILITY LOSS (MW Net) | | | TOTAL CAPACITY LOSS (MWH) |
| Begin | | | No Outages for November. | | None | 0.00 | 0 | /// | // | 0.00 |
| End | | | | | | | | | | |
| GOND | ER TOTA | ALS | | | 0 | 0.00 | | | /// | 0.00 |
| AC S | YSTEM T | OTALS | | | 0 | 0.00 | /// | | | 0.00 |

IPSC EMPLOYMENT STATISTICAL REPORT NOVEMBER 2004

DECEASED

D. NO. NAME DATE JOB TITLE

NONE

RETIRED

D. NO. NAME DATE JOB TITLE

00825 DALE HURD 11-05-04 ASST SUPT OF MAINTENANCE 16759 RONALD OLCOTT 11-30-04 AUXILIARY OPERATOR B

TERMINATIONS

D. NO. NAME DATE JOB TITLE

NONE

TERMINATION - MEDICAL DISABILITY

D. NO. NAME DATE JOB TITLE

NONE

NEW HIRES

D. NO. NAME DATE EMPLOYER JOB TITLE SUPV.

28669 JOSEPH F. PRUITT 11-22-04 APEX ALARM LABORER B. MORRIS

PROMOTIONS

NAME DATE JOB TITLE FROM AND TO

CLARK NIELSON 11-03-04 ENGINEER - LEAD ENGINEER

KENNETH LEBBON 11-08-04 ASST SUPT OPERATIONS - ASST SUPT MAINTENANCE SCOTT ROBISON 11-08-04 OPERATING SUPERVISOR - ASST SUPT OPERATIONS STEVE DRAPER 11-15-04 AUXILIARY OPERATOR B - OPERATING SUPERVISOR

TRANSFERS

NAME DATE JOB TITLE FROM AND TO

NONE

INACTIVE - MEDICAL DISABILITY

D. NO. NAME DATE JOB TITLE

22085 RUSSELL DEWSNUP 11-29-04 LABORER

IPSC PERFORMANCE INCENTIVE PROGRAM MONTHLY STATUS REPORT FOR NOVEMBER, 2004

| | | | | Mini | mum | Maxi | imum | | |
|---|---|------------------------|---|--------|------------------|--------|------------------|--------------|-------------------------------|
| | | Area of Performance | Performance Measure | Value | Incentive (%) | Value | Incentive (%) | YTD Value | Possible Year End Value |
| | 1 | Safety | | | | | | | |
| ł | | Lost Time Accidents | Lost Time Incident Rate | 2 | 0 | 0.5 | 15 | 0.55 | 0.22 |
| | | Accidents | Fatality | 1 | 0 | 0 | 3 | 0 | 0 |
| 1 | | Severity of Injuries | Lost Days Per 200,000 Hours of Exposure | 26 | 0 | 13 | 12 | 13.63 | 5.4 |
| • | | Resolution of Issues | Unresolved Citations - OSHA or Others | 2 | 0 | 0 | 2 | 0 | 0 |
| ı | | Cleanliness | | Qual. | 0 | Qual. | 3 | 0 | 3 |
| | | | | | | Totals | 35 | | |
| 1 | 2 | Environmental | | ţ | | | | | l |
| | | Notices of Violation | Number Issued | 2 | 0 | 0 | 2 | 0 | 0 |
| İ | | Wepco | Number of Months Targets Met | 0 | 0 | 12 | 3 | 4 | 12 |
| 3 | | Flue Gas Opacity | % of Time Opacity > 20% | 5% | 0 | 0.70% | 3 | 0.20% | 0.43% |
| 1 | | CEMS | Availability (Percent on-line) | 96% | 0 | 98% | 1 | 99.71 | 99.88% |
| 1 | | | | | | Totals | 9 | | |
| ı | 3 | Production | | | | | | | |
| 1 | | IGS Availability | Equivalent Availability | 87% | 5 | 92% | 10 | 99.77% | 94.56% |
| | | IPF Outages | Forced IPF Outages for ICS/ISY/IGS | 15 | 0 | 5 | 10 | 5 | 5 |
| | | IGS Outages | Forced Outage Rate | 2.00% | 0 | 1.00% | 6 | 0.22% | 0.10% |
| 1 | | STS Availability | Equivalent Availability | 95% | 0 | 97% | 2 | 100.00% | 100.00% |
| | | IGS Efficiency | Compare Heat Rate to Best Achievable | 2.50% | 0 | 0 | 5 | 0.80% | 0.50% |
| | | IGS Efficiency | Gross Heat Rate | 9050 | 0 | 9000 | 5 | 8998 | 9000 |
| 1 | | | | | | Totals | 38 | | 1 |
| | 4 | Maintenance | | | | | | | |
| | | Preventive Maintenance | Breakdown Hours/Total Maint. Hours | 15% | 0 | 11% | 2 | 11.48% | 11.00% |
| 1 | | Railcar Service Center | Unit Train Availability | 99% | 0 | 100% | 2 | yes | yes |
| İ | | | Maintain AAR Certification | No | 0 | Yes | 1 | yes | yes |
| ı | | | | | | Totals | 5 | | |
| | 5 | Budget | | ļ | | | | | |
| | | Expenditures | Total Actuals vs Estimates | 100% | 6 | 95% | 7 | 95.00% | 95.00% |
| | | Revenue | Income (\$Millions) | \$0.50 | 0 | \$1.00 | 2 | \$0.33 | \$1.00 |
| | | Employee Development | Training Sessions Completed | 92% | 0 | 100% | , 4 | 44.80% | 100.00% |
| L | | · | | | | Totals | 13 | | |

INTERMOUNTAIN GENERATING STATION



MONTHLY PRODUCTION REPORT NOVEMBER, 2004

GENERATION

| Station | | Unit #1 | Unit #2 | Facility | |
|-------------------------|-------------|---------------------------|---------------|-----------------|------------|
| Gross Generation | (Mw-hr) | 661,354 | 661,926 | 1,323,280 | |
| Auxiliary Power | (Mw-hr) | 37,711 | 38,317 | 76,028 | |
| Percent Aux Power | (%) | 5.70 | 5.79 | 5.75 | • |
| Net Facility Generation | (Mw-hr) | 623,643 | 623,609 | 1,247,252 | |
| HEAT RATE | | | | | |
| | | Unit #1 | Unit #2 | Facility | |
| Gross Unit Heat Rate | (Btu/kw-hr) | 8,988 | 8,999 | 8,993 | |
| Net Facility Heat Rate | (Btu/kw-hr) | 9,531 | 9,552 | 9,542 | |
| FUEL | | | | | |
| USAGE | | Unit #1 | Unit #2 | Station | |
| Coal Usage | (tons) | 272,742 | 273,254 | 545,996 | |
| Fuel Oil | (gallons) | 15,067 | 26,009 | 41,076 | |
| Fuel Oil Heat Input | (%) | 0.03 | 0.06 | 0.05 | |
| INVENTORY | | ¹ Starting Inv | Deliveries | Usage | Ending Inv |
| Total Coal | (tons) | 465,919 | 539,354 | 545,996 | 459,277 |
| Fuel Oil | (gallons) | 793,170 | 0 | 41,076 | 752,094 |
| QUALITY | | | | | |
| - | as-fired) | | Fu | el Oil (as-fire | d) |
| Heating Value | (Btu/lb) | 10,893 | Heating Value | (Btu/lb) | 19,159 |
| Sulfur | (%) | 0.54 | Density | (lb/gal) | 7.18 |
| Ash | (%) | 12.45 | Sulfur | (%) | 0.21 |
| AQCS PERFORMANCE | 4 | | | | |
| | | Unit #1 | Unit #2 | | |
| Stack Opacity | (%) | 2.30 | 4.30 | | |
| SO2 Emissions | (lbs/MBtu) | 0.05 | 0.05 | | |
| Scrubber Removal | (%) | 95.0 | 95.0 | | |
| NOx Emissions | (lbs/MBtu) | 0.36 | 0.33 | | |

¹ October 2004 starting coal inventory corrected for delivery errors in August & September, 2004

AVAILABILITY (IGF)

(IGF includes production (IGS), conversion (ICS), and transmission (STS) systems)

| | | Unit #1 | Unit #2 | Facility |
|---------------------------|---------|---------|---------|----------|
| # Unit Shutdowns | | 1 | 0 | 1 |
| Forced Outage Hours | | 2.10 | 0.00 | 2.10 |
| Maintenance Outage Hou | ırs | 0.00 | 0.00 | 0.00 |
| Planned Outage Hours | | 0.00 | 0.00 | 0.00 |
| Reserve Shutdown Hours | S | 0.00 | 0.00 | 0.00 |
| Total Hours Off-line | | 2.10 | 0.00 | 2.10 |
| Equi Forced Derate Hou | rs | 0.37 | 3.49 | 3.86 |
| Equi Maintenance Derat | e Hours | 0.00 | 0.00 | 0.00 |
| Equi Planned Derate Ho | urs | 0.00 | 0.00 | 0.00 |
| Total Equivalent Derate H | Hours | 0.37 | 3.49 | 3.86 |
| Availability | (%) | 99.71 | 100.00 | 99.85 |
| Eq Availability Factor | (%) | 99.66 | 99.52 | 99.59 |
| Forced Outage Rate | (%) | 0.29 | 0.00 | 0.15 |
| Eq Forced Outage Rate | (%) | 0.34 | 0.48 | 0.41 |
| Eq Unplan Outage Rate | (%) | 0.34 | 0.48 | 0.41 |
| Net Capacity Factor | (%) | 96.24 | 96.24 | 96.24 |
| Net Output Factor | (%) | 96.52 | 96.24 | 96.38 |

MONTHLY EVENT REPORT November, 2004

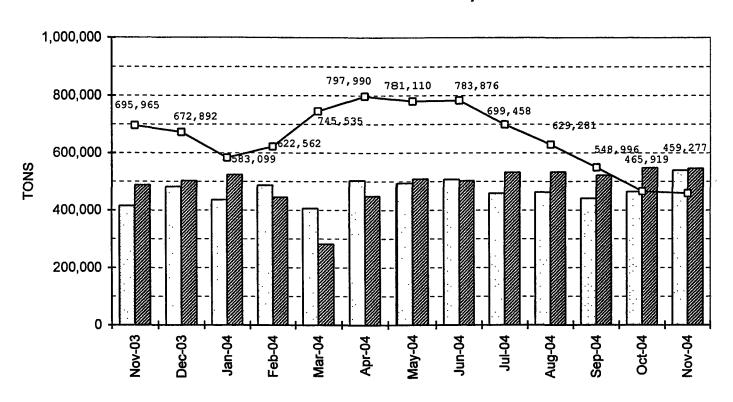
| DATE, TIME- START DATE, TIME- END | DESCRIPTION | EVENT TYPE | OUTAGE DURATION HOURS | | ATE ATION EQ HRS | CAPABILITY LOSS MW net | | AVAIL ACITY STATION | TOTAL CAPACITY LOSS (MWH) |
|--|--|-------------------|-----------------------------|-------|------------------------|------------------------------|------|---------------------------|---------------------------------|
| UNIT 1 11/3/2004 9:18 11/3/2004 11:24 | FORCED OUTAGE Low drum level trip due to loss air press causing recircs to open. | Forced | 2.10 | | | 900 | 0 | 900 | 1,890 |
| 11/6/2004 23:19 11/7/2004 0:00 | FORCED DERATE 1C vacuum pump trip. 1D would not start. SUS 1B4 trip. | Forced | | 0.68 | 0.08 | 109 | 791 | 1,691 | 74 |
| 11/29/2004 18:37 11/29/2004 22:07 | FORCED DERATE 6 pulverizer operation. G fdr failed controller replacement. | Forced | | 3.50 | 0.29 | 75 | 825 | 1,725 | 263 |
| TOTAL (for Uni | • | 3 | 2.10 | 4.18 | 0.37 | | ···· | • | 2,227 |
| UNIT 2 11/14/2004 0:20 11/14/2004 2:55 | FORCED DERATE Lowered load to grind out pulverizers. Lower BTU coal. | Forced | | 2.58 | 0.45 | 156 | 744 | 1,644 | 403 |
| 11/14/2004 3:48 11/14/2004 11:28 | FORCED DERATE High pulv DP's and motor amps due to dirt/rocks in coal. | Forced | | 7.67 | 0.74 | 87 | 813 | 1,713 | 667 |
| 11/16/2004 10:45 11/17/2004 18:52 | FORCED DERATE Intermittant 6 pulverizer operation with lower BTU coal. Ave load over time. | Forced | | 32.12 | 1.71 | 48 | 852 | 1,752 | 1,542 |
| 11/20/2004 18:08 11/20/2004 19:00 | FORCED DERATE 6 pulverizer operation. F pulv PA flow trip. Lower BTU coal. | Forced | | 0.87 | 0.14 | 142 | 758 | 1,658 | 123 |
| 11/21/2004 20:42 11/21/2004 21:24 | FORCED DERATE 6 pulverizer operation. D pulv trip. Lower BTU coal. | Forced | | 0.70 | 0.05 | 63 | 837 | 1,737 | 44 |
| 11/27/2004 0:09 11/27/2004 3:50 | FORCED DERATE Pulverizer loading problems. Lower BTU coal. | Forced | | 3.68 | 0.31 | 75 | 825 | 1,725 | 276 |
| 11/28/2004 1:04 11/28/2004 2:02 | FORCED DERATE 6 pulverizer operation. F fdr drag chain motor replacement. | Forced | | 0.97 | 0.09 | 85 | 815 | 1,715 | 82 |
| TOTAL (for Un | | 7 | 0.00 | 48.58 | 3.49 | | | | 3,137 |
| TOTAL (FOR | IGS) | 10 -10- | 2.10 | 52.77 | 3.86 | | | | (5,364) |

^{*} Incidente not charged against IDSC Parformance Incentive Program

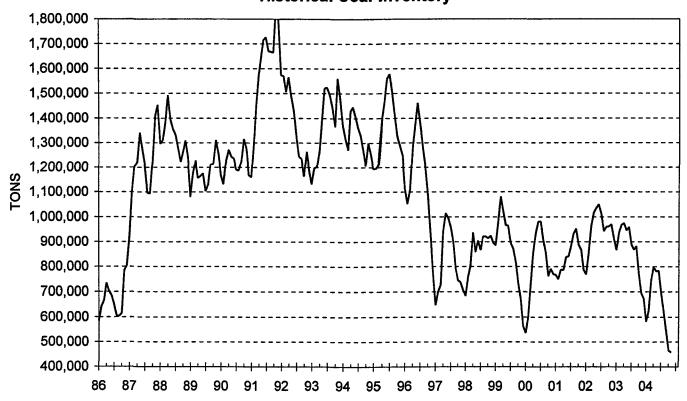
INTERMOUNTAIN GENERATING STATION PRODUCTION REPORT HISTORICAL TRENDS

12 MONTH COAL INVENTORY

Deliveries ZZZZ Burn — Inventory



Historical Coal Inventory



INTERMOUNTAIN GENERATING STATION



MONTHLY PRODUCTION REPORT FISCAL YEAR TO DATE (7/1/04 - 11/30/04)

GENERATION

| | Station | | Unit #1 | Unit #2 | Facility | |
|------|-------------------------|-------------|--------------|---------------|-------------------|-------------------|
| | Gross Generation | (Mw-hr) | 3,392,900 | 3,417,307 | 6,810,207 | |
| | Auxiliary Power | (Mw-hr) | 194,644 | 192,406 | 387,050 | |
| | Percent Aux Power | (%) | 5.74 | 5.63 | 5.68 | |
| | Net Facility Generation | (Mw-hr) | 3,198,256 | 3,224,901 | 6,423,157 | |
| HEA' | T RATE | | | | | |
| | | | Unit #1 | Unit #2 | Facility | |
| | Gross Unit Heat Rate | (Btu/kw-hr) | 9,000 | 8,996 | 8,998 | |
| | Net Facility Heat Rate | (Btu/kw-hr) | 9,548 | 9,532 | 9,540 | |
| FUE | L | | | | | |
| | USAGE | | Unit #1 | Unit #2 | Station | |
| | Coal Usage | (tons) | 1,336,661 | 1,345,627 | 2,682,288 | |
| | Fuel Oil | (gallons) | 75,820 | 69,636 | 145,456 | |
| | Fuel Oil Heat Input | (%) | 0.03 | 0.03 | 0.03 | |
| | INVENTORY | | Starting Inv | Deliveries | Usage | Ending Inv |
| | Total Coal | (tons) | 773,381 | 2,368,184 | 2,682,288 | 459,277 |
| | Fuel Oil | (gallons) | 886,073 | 11,476 | 145,456 | 752,093 |
| | QUALITY | | | | | |
| | Coal (a | s-fired) | | Fu | el Oil (as-fired) | |
| | Heating Value | (Btu/lb) | 11,419 | Heating Value | (Btu/lb) | 19,203 |
| | Sulfur | (%) | 0.58 | Density | (lb/gal) | 7.16 |
| | Ash | (%) | 11.54 | Sulfur | (%) | 0.24 |
| AQC | S PERFORMANCE | | | | | |
| | | | Unit #1 | Unit #2 | | |
| | Stack Opacity | (%) | 2.46 | 3.55 | | |
| | SO2 Emissions | (lbs/MBtu) | 0.04 | 0.05 | | |
| | Scrubber Removal | (%) | 95.4 | 94.8 | | |
| | Nox Emissions | (lbs/MBtu) | 0.36 | 0.35 | | |

AVAILABILITY (IGF)

(IGF includes production (IGS), conversion (ICS), and transmission (STS) systems)

| | | Unit #1 | Unit #2 | Facility |
|-------------------------------|------|---------|---------|----------|
| # Unit Shutdowns | | 5 | 0 | 5 |
| Forced Outage Hours | | 9.70 | 0.00 | 9.70 |
| Maintenance Outage Hou | ırs | 0.00 | 0.00 | 0.00 |
| Planned Outage Hours | | 0.00 | 0.00 | 0.00 |
| Reserve Shutdown Hours | | 0.00 | 0.00 | 0.00 |
| Total Hours Off-line | | 9.70 | 0.00 | 9.70 |
| Equi Forced Derate Hou | 1.69 | 5.03 | 6.72 | |
| Equi Maintenance Derate Hours | | 0.00 | 0.31 | 0.31 |
| Equi Planned Derate Hours | | 0.00 | 0.00 | 0.00 |
| Total Equi Derate Hours | | 1.69 | 5.34 | 7.03 |
| Availability | (%) | 99.74 | 100.00 | 99.87 |
| Eq Availability Factor | (%) | 99.69 | 99.85 | 99.77 |
| Forced Outage Rate | (%) | 0.26 | 0.00 | 0.13 |
| Eq Forced Outage Rate | (%) | 0.31 | 0.14 | 0.22 |
| Eq Unplan Outage Rate | (%) | 0.31 | 0.15 | 0.23 |
| Net Capacity Factor | (%) | 96.75 | 97.56 | 97.15 |
| Net Output Factor | (%) | 97.01 | 97.56 | 97.28 |

MAJOR CAUSES OF MEGAWATT HOUR LOSS BY OUTAGE CLASSIFICATION

FISCAL YEAR TO DATE (7/1/04 - 11/30/04)

| DESCRIPTION PLANNED OUTAGES | | 07407 | TIME DURATION EQUIV HOURS UNIT 1 UNIT 2 | | MW HRS LOST | |
|-----------------------------|--|---------------|---|------|-------------|--------|
| | | START DATE | | | UNIT 1 | UNIT 2 |
| | SUBTOTAL | 0 | 0.00 | 0.00 | 0 | 0 |
| MA | AINTENANCE OUTAGES (UNPLANNED) | | | | | |
| | SUBTOTAL | 0 | 0.00 | 0.00 | 0 | 0 |
| FO | B BFPT tripped during weekly overspeed testing. Drum level trip. | 8/7/2004 | 2.10 | | 1,890 | |
| | Drum level trip when A BFPT tripped. B BFPT o/s troubleshooting. | 8/7/2004 | 1.40 | | 1,260 | |
| | Drum level trip. High drum press forced S/B BFP out of hdr. | 8/7/2004 | 1.18 | | 1,065 | |
| | Turbine trip on loss of stator cooling water indication. | 9/14/2004 | 2.92 | | 2,625 | |
| | Low drum level trip due to loss air press causing recircs to open. | 11/3/2004 | 2.10 | | 1,890 | |
| | SUBTOTAL | 5 | 9.70 | 0.00 | 8,730 | 0 |
| RE | SERVE SHUTDOWN (UNIT OFFLINE) | | | | | |
| | SUBTOTAL | 0 | 0.00 | 0.00 | 0 | 0 |
| | TOTAL OFF-LINE | 5 | 9.70 | 0 | 8,730 | 0 |

NOTES: * Trips not charged against IPSC Performance Incentive Program

MAJOR CAUSES OF MEGAWATT HOUR LOSS BY OUTAGE CLASSIFICATION

FISCAL YEAR TO DATE (7/1/04 - 11/30/04)

| DESCRIPTION | START | TIME DURATION EQUIV HOURS | | MW HRS LOST | |
|---|------------|---------------------------|--------|-------------|--------|
| MAINTENANCE DERATES | DATE | UNIT 1 | UNIT 2 | UNIT 1 | UNIT 2 |
| B BFPT o/s on bid to replace trip and overspeed solenoids. | 8/17/2004 | | 0.31 | | 283 |
| Total Maintenance Derates | 1 | 0.00 | 0.31 | 0 | 283 |
| PLANNED DERATES | | | | | |
| Total Planned Derates | 0 | 0.00 | 0.00 | 0 | 0 |
| FORCED DERATES | | | | | |
| 6 pulv operation. Unable to maintain full load. | 7/3/2004 | | 0.40 | | 360 |
| 1B FD Fan PMCS. Remote I/O head replaced. | 7/13/2004 | | 0.08 | | 72 |
| 6 pulv operation. Unable to reach full load. | 7/21/2004 | | 0.13 | | 116 |
| 5 pulv operation. E o/s maint, B fdr replacement, C pulv tripped. | 7/30/2004 | | 0.17 | | 153 |
| A BFPT o/s troubleshooting. Load limit 850 mw. | 8/7/2004 | 0.43 | | 388 | |
| A BFPT o/s. Active thrust wear trip press switch 190 replaced. | 8/7/2004 | 0.77 | | 690 | |
| E pulv o/s maint, G fdr problems, H pulv tripped. 5 pulv operation. | 8/16/2004 | | 0.25 | | 227 |
| 6 pulv operation with lower BTU coal. Unable to maintain load. | 9/20/2004 | 0.12 | | 111 | |
| 6 pulv operation with lower BTU coal. Unable to maintain load. | 9/25/2004 | | 0.37 | | 333 |
| 6 pulv operation. H pulv PA flow problems. Lower BTU coal. | 9/25/2004 | | 0.14 | | 125 |
| 1C vacuum pump trip. 1D would not start. SUS 1B4 trip. | 11/6/2004 | 0.08 | | 74 | |
| Lowered load to grind out pulverizers. Lower BTU coal. | 11/14/2004 | | 0.45 | | 403 |
| High pulv DP's and motor amps due to dirt/rocks in coal. | 11/14/2004 | | 0.74 | | 667 |
| Intermittant 6 pulv operation with lower BTU coal. Ave load. | 11/16/2004 | | 1.71 | | 1,542 |
| 6 pulv operation. F pulv PA flow trip. Lower BTU coal. | 11/20/2004 | | 0.14 | | 123 |
| 6 pulverizer operation. D pulv trip. Lower BTU coal. | 11/21/2004 | | 0.05 | | 44 |

MAJOR CAUSES OF MEGAWATT HOUR LOSS BY OUTAGE CLASSIFICATION

FISCAL YEAR TO DATE (7/1/04 - 11/30/04)

| DESCRIPTION | | TIME DURATION | | MW HRS LOST | |
|--|---------------|---------------|-----------------|-------------|--------|
| FORCED DERATES | START DATE | UNIT 1 | HOURS UNIT 2 | UNIT 1 | UNIT 2 |
| Pulverizer loading problems. Lower BTU coal. | 11/27/2004 | | 0.31 | | 276 |
| 6 pulv operation. F fdr drag chain motor replacement. | 11/28/2004 | | 0.09 | | 82 |
| 6 pulv operation. G fdr failed controller replacement. | 11/29/2004 | 0.29 | | 263 | |
| Total Forced Derates | 19 | 1.69 | 5.03 | 1,526 | 4,523 |
| TOTAL DERATES | 20 | 1.69 | 5.34 | 1,526 | 4,806 |

NOTES: ** Derates not charged against IPSC Performance Incentive Program